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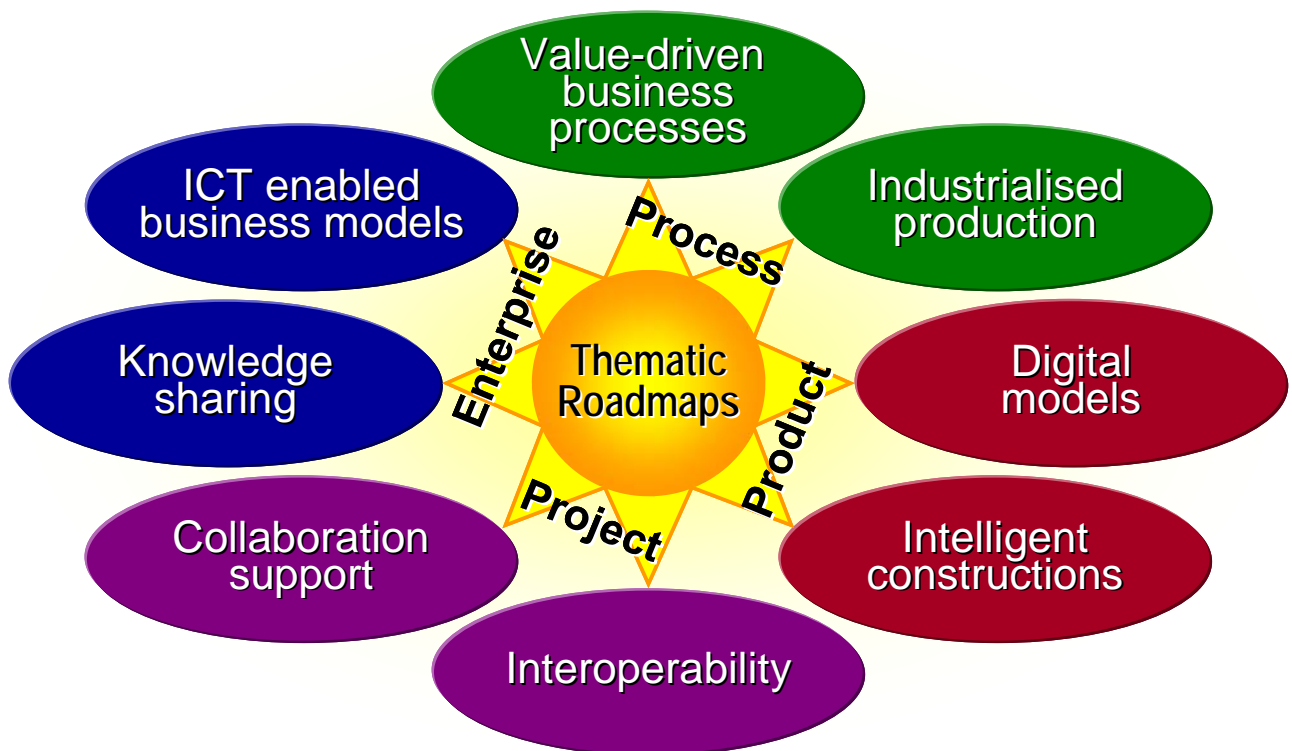


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# Strategic Roadmaps and Implementation Actions for ICT in Construction



**Strategic Actions for Realising the Vision of ICT in Construction**

[www.strat-con.org](http://www.strat-con.org)

Dr. Abdul Samad (Sami) Kazi & Matti Hannus, VTT, Finland

Dr. Alain Zarli, CSTB, France

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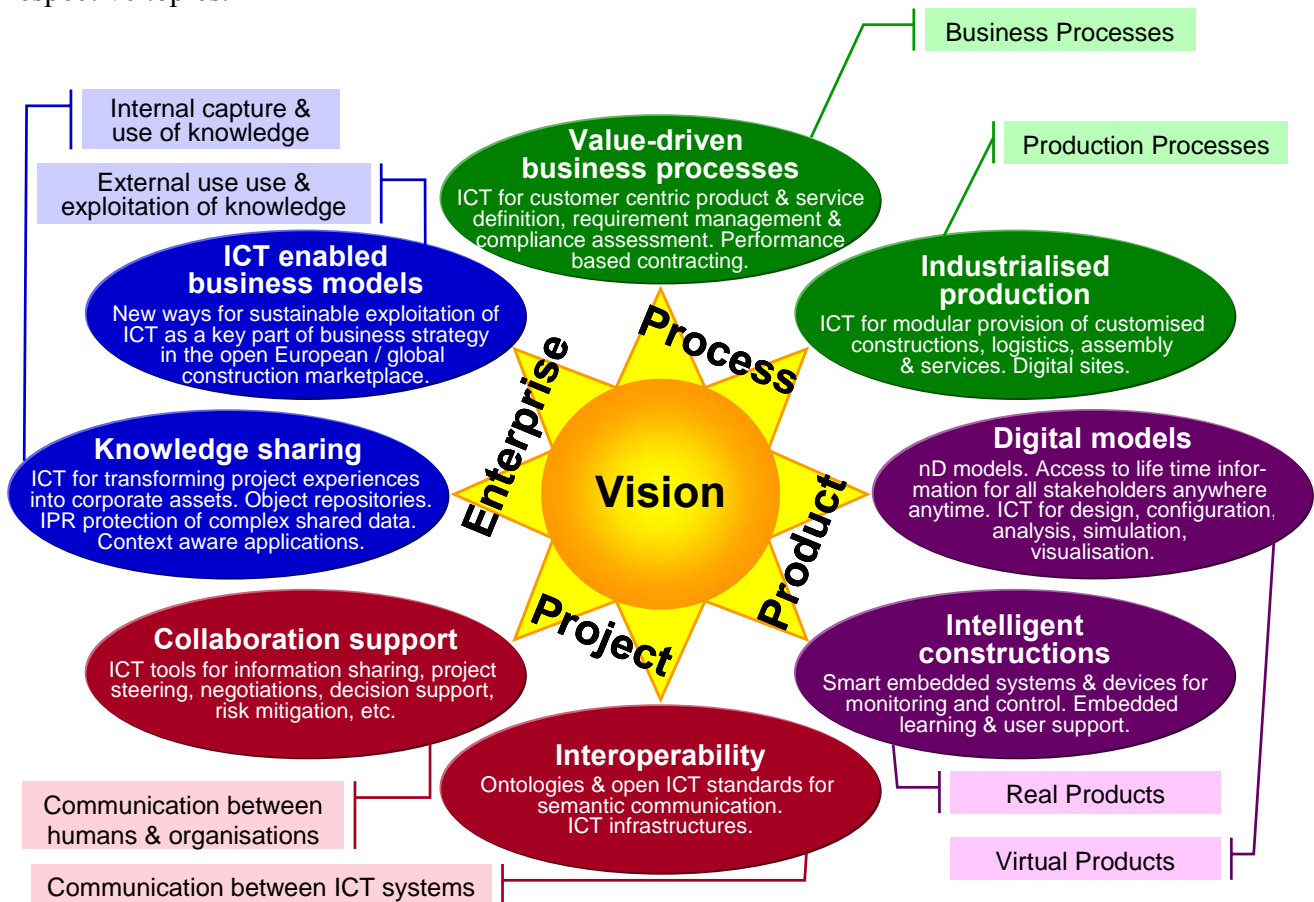
TU - Wien, Vienna University of Technology, Austria (<http://www.tuwien.ac.at/>)

Strat-CON has been partially funded through the collaboration of different national programmes promoting sustainable construction and operation of buildings under the ERABUILD programme ([www.erabuild.net](http://www.erabuild.net)).

# Executive Summary

The construction sector is characterised by delivery of one-of-a-kind product and service delivery through competence sharing between different organisations (some of which may be unknown to others). ICT usage in the sector is limited and lags far behind other manufacturing sectors. The ROADCON project offered a vision for ICT in construction in addition to a set of roadmaps across 12 thematic areas. It did not however provide a means (in terms of research plans) for realisation of the vision. This report presents the Strat-CON project which was initiated to align the ROADCON roadmaps with the main thematic areas addressed by the European Construction Technology Platform's focus area on processes and ICT. Strat-CON furthermore through stakeholder interaction, has identified and developed a set of strategic actions for realising the vision of ICT in construction.

Figure P - 1 illustrates the eight main themes (for whom roadmaps were developed) along with their respective topics.

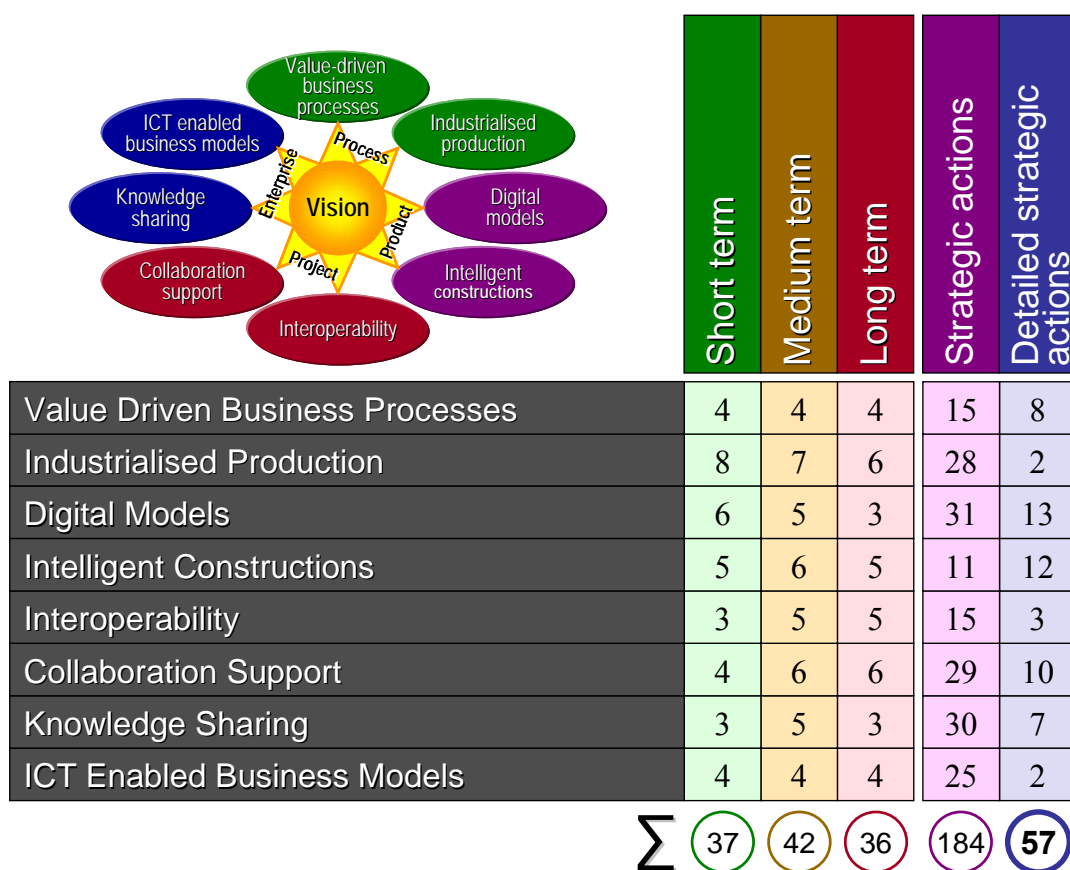


**Figure P - 1: Main Themes and Corresponding Topics**

A set of key business drivers were identified for each roadmap supported by a set of key research topics (see Table P - 1). Furthermore, a set of short, medium and long term items (research topics) in terms of time-to-industry were identified for each roadmap. Through a series of interactive international workshops for each roadmap a list of strategic actions were identified to support realisation of the short, medium and long term items identified. Furthermore, some of the identified strategic actions were detailed. An overall summary of the Strat-CON project outputs is presented in Figure P - 2.

**Table P - 1: Main Themes and Corresponding Business Drivers and Key Research Topics**

Themes	Main Business Drivers	Key Research Topics
Value-driven business processes	performance-driven process, value to customer, total life-cycle support, product and service customisation	performance-driven processes, process orchestration, metrics, indicators, requirements engineering, mass customisation
Industrialised production	supply chain management, just in time logistics => open market, site productivity => ambient manufacturing and construction	ICT for modular provision of customised constructions, logistics, assembly & services, digital sites.
Digital models	semantics and interoperability => user and lifecycle orientation => real-time adaptive models.	nD models, access to life time information for all stakeholders anywhere anytime; ICT for design, configuration, analysis, simulation, and visualisation.
Intelligent Constructions	integrated automation and control (connectivity) => remote diagnostics and control (serviceability) => context-aware seamless configurability (adaptability)	smart embedded systems & devices for monitoring and control, embedded learning & user support.
Interoperability	date/file exchange => data sharing => flexible interoperability	model servers, distributed adaptive components, ontologies & open ICT standards for semantic communication, ICT infrastructures
Collaboration support	rapid and easy connectivity => robust team interaction => seamless inter-enterprise integration	ICT tools for information sharing, project steering, negotiations, decision support, risk mitigation, etc.
Knowledge sharing	access to knowledge => sharing structured knowledge => context-aware knowledge	ICT for transforming project experiences into corporate assets. Object repositories, IPR protection of complex shared data, context aware applications.
ICT enabled business models	business networking, customer orientation & sustainability, system integration, specialisation	new ways for sustainable exploitation of ICT as a key part of business strategy in the open European / global construction marketplace



**Figure P - 2: Overall Summary of Strat-CON outputs**

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# Preface

## Overview of Strat-CON

### Background

In 2003, the European ROADCON<sup>1</sup> (2003) project was launched to define the vision for ICT (information and communications technology) in construction. It was purposely structured to provide possible topics for take-up, development, research, and exploration of emerging technologies to be funded under the Information Society Technologies priority of the 6<sup>th</sup> Framework Programme of the European Commission.

In 2004, the European Construction Technology Platform<sup>2</sup> (ECTP) was established to define that “Vision 2030” and to provide a “Strategic Research Agenda” for the construction sector. These were to initially cover six main focus areas: underground construction, cities and buildings, quality of life, materials, networks, and cultural heritage. A key aim was to provide areas for funding under the then forthcoming 7<sup>th</sup> Framework Programme of the European Commission.

In October of 2005, the need for a focus area covering processes and ICT was realised and in response, the seventh focus area (FA7) of the ECTP, “Processes and ICT” was established. The focus of FA7 was on four main thematic areas (processes, products, projects, and enterprises) supported through ICT.

In May 2006, the Strat-CON project was launched as one of the first projects on “Managing Information in Construction” under ERABUILD (2006). One of its aims was to support FA7 in the definition and development of the Vision 2030 and corresponding Strategic Research Agenda for Processes and ICT.

### Main Objectives and Key Results

The main objectives and key expectations (results) from Strat-CON can be summarised as follows:

- Updated and refined vision and roadmap for ICT in building construction.
- Suggestions and guidelines for the implementation of strategic research, development and take-up actions from an industrial perspective.
- Validation of the proposed strategy by both research and industry communities.
- Contributions to the Vision 2030 and the Strategic Research Agenda of the ECTP and FA7.

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<sup>1</sup> <http://cic.vtt.fi/projects/roadcon>

<sup>2</sup> <http://www.ectp.org>



## Structure of Content

The aim of this publication is to present some of the key findings from Strat-CON that lasted between May 2006 and September 2007. Its contents are structured as follows:

- **Introduction:** This section presents the context, main thematic areas, and key topics considered.
- **Approach:** This section describes the Strat-CON approach for roadmap development and strategic implementation action definition. Furthermore, it presents the different perspectives of innovation considered in Strat-CON.
- **Roadmap:** Each of the eight roadmaps (value-driven business processes, industrialised production, digital models, intelligent constructions, interoperability, collaboration support, knowledge sharing and ICT enabled business models) is presented in an individual section with each section structured as follows:
  - Background
  - Vision
    - Target State
    - Business Scenario(s)
  - Roadmap
    - Objectives
    - Main Research Areas
      - Current State of the Art
      - Time to Industry: Short term
      - Time to Industry: Medium term
      - Time to Industry: Long term
  - Business Impacts
  - Thematic Mapping and Further Information
- **Strat-CON: Key Lessons Learned:** This section provides some of the key lessons learned during the course of Strat-CON in terms of development of roadmaps and definition of strategic implementation actions.
- **Appendices:** The main content of this publication is supported by five appendices as follows:
  - Appendix A: List of Strategic Actions
  - Appendix B: Detailed Strategic Actions
  - Appendix C: Strat-CON – FIATECH
  - Appendix D: Strat-CON Mappings
  - Appendix E: Re-use of Strat-CON Approach

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- All individuals who contributed to the identification and especially development of details strategic actions (please refer to Appendix B for the detailed strategic actions and their respective contributors).
- The numerous individuals who took the time and effort to attend and provide feedback at our various interactive workshops in Austria, Finland, France, Korea, Spain, the United Kingdom, and the United States of America.

Strat-CON has been partially funded through the collaboration of different national programmes promoting sustainable construction and operation of buildings under the ERABUILD programme. These national programmes include the Finnish Funding Agency for Technology and Innovation (TEKES), the French Ministry of Equipment (Ministère de l'Écologie, du Développement et de l'Aménagement Durables) under the CSTB research programme, and the Austrian Program on Technologies for Sustainable Development (HAUS der Zukunft).

## Contact Information

For more information on Strat-CON please visit, [www.strat-con.org](http://www.strat-con.org), or contact the core team.

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# Introduction

## Context

The European construction sector today constitutes 2.3 million enterprises (mainly SMEs) of which 96% employ less than 20 employees. At the same time, the sector is the largest in terms of employment in the EU with a GDP contribution of 9.8% and an overall employment rate of 7.1% of the European workforce (e-Business w@tch, 2005).

The construction sector is characterised by collaboration between many stakeholders who work together in projects for limited periods of time (Kazi et al. 2001). Other key characteristics include the complexity and long life cycle of products. Therefore it is only natural that the current use of information and communications technologies (ICT) is fragmented serving specific tasks, stakeholders and life cycle stages. The main challenge for the construction sector is to achieve holistic and integrated ICT support covering the complete project life cycle from conception to demolition. Yet the construction sector lags significantly behind other manufacturing sectors (e.g. manufacturing, publishing and printing, automotive, pharmaceutical, etc.) in terms of basic ICT infrastructure, ICT for internal processes, supply-side e-business activities, and electronic marketing and sales (e-Business w@tch, 2005).

The ROADCON project (2003) identified the vision for future ICT in construction to be, “*Construction sector is driven by total product life performance and supported by knowledge-intensive and model based ICT enabling holistic support and decision making throughout the various business processes and the whole product life cycle by all stakeholders*”. To realise this vision a set of inter-related sub-roadmaps spanning twelve thematic areas were identified (Figure 1). Within each, a set of RTD topics were identified: ready for take-up, development, research, and emerging.

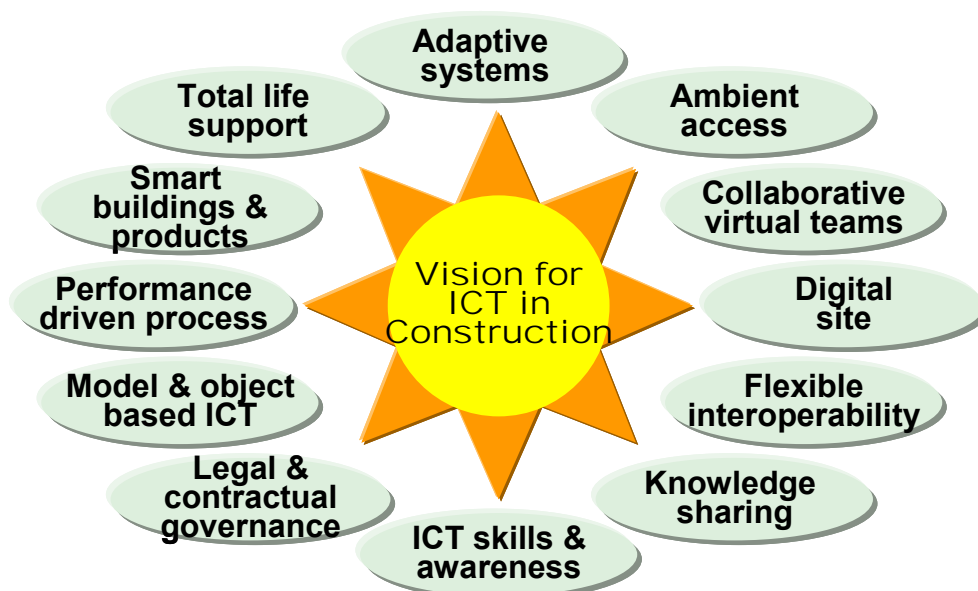


Figure 1: Thematic areas covered by ROADCON (2003)

The ROADCON roadmap (2003) was developed based on contributions from more than fifty experts in various EU countries with support from an industrial support group of 293 organisations spanning 30 countries. Due to limited resources and a strict schedule, ROADCON (2003) only offered a set of roadmaps identifying a set of research and development (R&D) topics. What it did not however offer was a set of streamlined actions (project ideas, plans, etc.) that could be used by both researchers and industry to actually realise the vision for ICT in construction.

## The Strat-CON Project

The Strat-CON (Strategic Actions for Realising the Vision of ICT in Construction) project (2006) carries on from where ROADCON (2003) ended. ROADCON while providing the vision and roadmaps did not however offer any action plans or project ideas whose realisation would lead to achievement of the vision. This task of identifying strategic actions for realising the vision of ICT in construction is the main goal of Strat-CON.

Strat-CON has three main scientific objectives as follows:

- Obj. 1: Refine, validate and if necessary re-develop vision and roadmap for ICT in construction,
- Obj. 2: Identify a set of strategic actions for realising the vision of ICT in construction, and
- Obj. 3: Validate strategic actions and provide guidelines for implementation.

Strat-CON was launched from May 2006 to September 2007, as one of the first projects on “Managing Information in Construction” under ERABUILD (2006). It worked in unison with members of Focus Area 7 (FA7) on Processes and ICT ([http://www.ectp.org/fa\\_pict.asp](http://www.ectp.org/fa_pict.asp)) of the European Construction Technology Platform (ECTP).

## Thematic Areas and Current State

FA7 of the ECTP has identified four main thematic areas of interest for processes and ICT. In addition to the roadmaps offered by ROADCON (2003), Strat-CON made use of these thematic areas when developing its roadmap(s) and identifying complementary strategic research actions.

The thematic areas considered were as follows:

- Processes: business processes and production processes.
- Products: digital modelling of products and intelligent constructions.
- Projects: interoperability between ICT systems and ICT support for collaborative work.
- Enterprises: capturing project experience into knowledge assets and exploiting them in new ICT enabled business models.

### Current State: Processes

- Business processes and competition are based on lowest project cost and short term antagonistic relationships rather than knowledge.
- Poor understanding and missing methodologies to assess and change value measurement, incentive drivers and contractual conditions.
- Production processes are dominated by on-site labour and low productivity off-site production.
- Low level of product differentiation makes companies vulnerable to increasing cross-border trade.

### Current State: Products

- Current ICT tools in the construction industry are based mainly on application-specific data or are at low semantic level such as (digital) 2D-drawings and textual specifications. This hampers automation and integration of processes.
- Semantic “nD” modelling is increasingly supported by proprietary software tools and interoperability standards.
- Sharing semantic data is hampered by insufficient protection of intellectual property.
- Products are designed and delivered to order, with low degree of configurable manufactured components.
- Current constructions are mainly “dumb”, poorly documented and difficult to use in an optimised way, while becoming increasingly complex due to use of new technologies.
- Existing intelligent (sub)systems are poorly integrated.

### **Current State: Projects**

- Despite promising developments of object modelling and data exchange standards such as IFC, increasing use of semantic "nD" applications continues to face huge interoperability challenges.
- Available solutions address static data but not dynamic product behaviour.
- Interoperability problems limit the potential benefits of new and emerging ICT, cause extensive information management overload, limit possibilities for business collaboration between geographically remote partners, and limit the introduction of new and innovative products & services to the market.
- Current collaborative environments ("project web sites") provide basic file/document management and basic collaboration tools.
- Use of advanced collaboration tools is constrained by short project durations and concurrent participation of stakeholders in many projects at the same time. This leads to difficulties regarding costs and learning to use multiple systems.
- A fundamental and growing problem is the disparity of internal enterprise systems and external project environments.
- In addition to CAD/CAE tools product data in other industry sectors is managed by so called PDM systems which are rarely used in construction. Generic PDM addresses document and work-flow management for large organisations and their suppliers. Consequently setting up a PDM system is time consuming, expensive and not feasible in a project oriented sector like construction.

### **Current State: Enterprises**

- The sector makes wide use of commonly available knowledge. Few organisations exploit project experiences for developing genuine competitive advantages.
- Current business processes provide low incentives for R&D and knowledge development.
- Current business model are based on lowest cost and capacity.
- Enlarging open market, evolving business processes and new technologies in combination open up rewarding opportunities to innovative companies to develop and offer new knowledge based products and services.
- Generic Knowledge Management has been target for exhaustive RTD so far. However, very little has been done for capturing project experiences, formalizing them into corporate assets and exploiting them in new business models. This remains a relevant opportunity for construction and faces little competition on RTD funding from other sectors.
- Enterprise Resource Planning (ERP) is an area where construction seems to be lagging behind other industry sectors. The applicability of mainstream ERP systems has been limited by the project oriented nature of construction.

## Thematic Areas and Main Topics

Each of the four thematic areas was broken down into two themes (research priorities), with each theme addressing one main topic as shown in Figure 2.

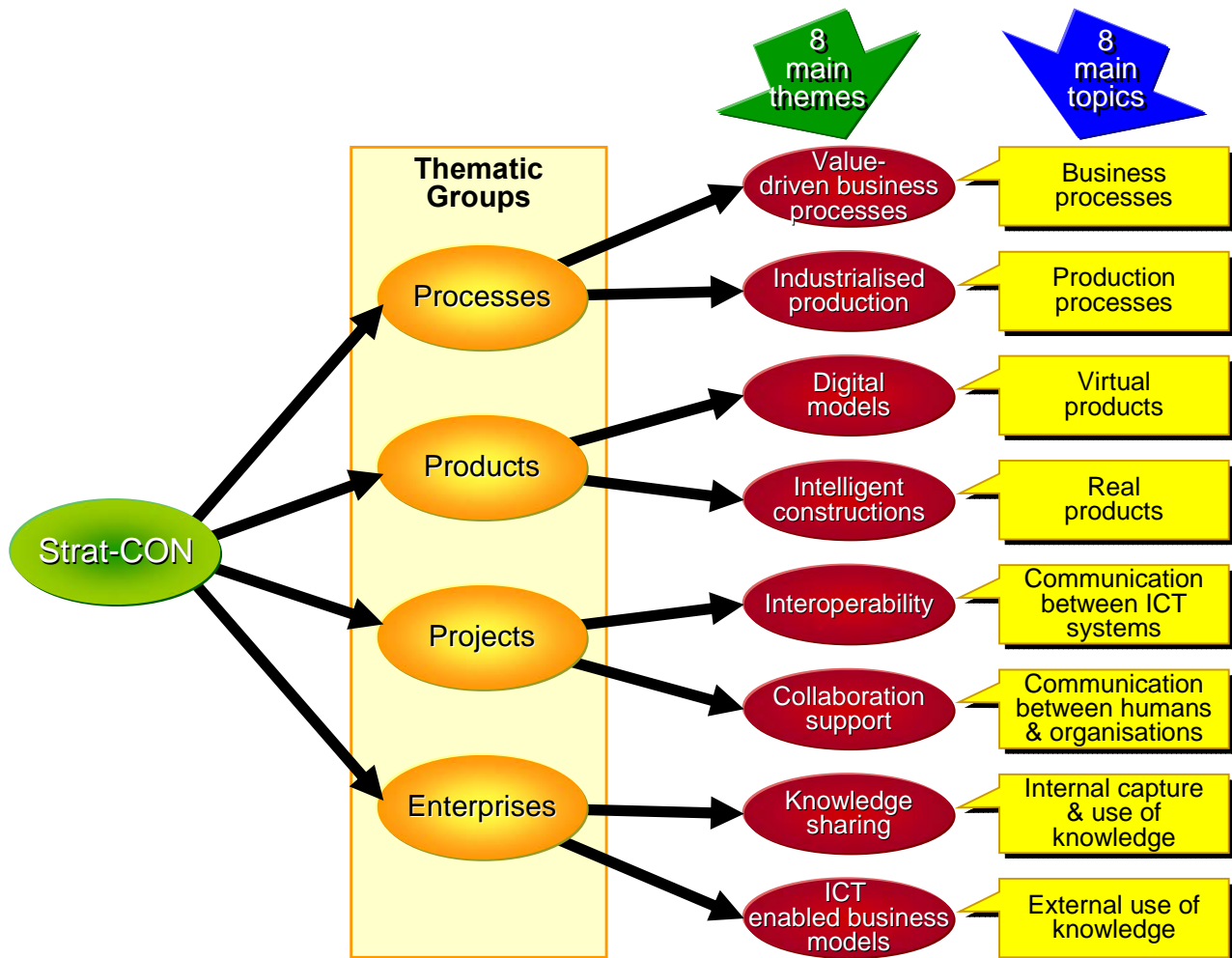


Figure 2: Thematic Areas and Main Topics



## Approach

To continuously evolve and innovate, organisations and industrial sectors need to set clear evolutionary paths facilitating a transition from a “current” state to an envisioned “future” state. Within Strat-CON a simple and visual methodology is used for developing strategic roadmaps supplemented with a set of implementation actions that support realisation of the elements of the roadmap. Using a futuristic visionary state as the goal, a set of short, medium, and long-time to industry actions are defined.

When developing the roadmaps and supporting strategic implementation actions, some key assumptions are made:

- Visions serve as the basis for continuous evolution and innovation
- Clear roadmaps define the path from today (as-is) to the desired vision (to-be)
- Strategic implementation actions provide the means to follow the roadmaps to achieve the vision

For more information on the overall approach, please refer to Kazi (2007).

## Setting Priorities

Relying on the thematic areas, and their corresponding themes and main topics, for each of the eight main themes, key priorities (requirements) were defined as shown in Table 1.

**Table 1: Main Themes and Corresponding Priorities**

Themes	Key Priorities
Value-driven business processes	ICT for customer centric product & service definition, requirement management & compliance assessment. Performance based contracting.
Industrialised production	ICT for modular provision of customised constructions, logistics, assembly & services. Digital sites.
Digital models	nD models. Access to life time information for all stakeholders anywhere anytime. ICT for design, configuration, analysis, simulation, visualisation.
Intelligent Constructions	Smart embedded systems & devices for monitoring and control. Embedded learning & user support.
Interoperability	Ontologies & open ICT standards for semantic communication. ICT infrastructures.
Collaboration support	ICT tools for information sharing, project steering, negotiations, decision support, risk mitigation, etc.
Knowledge sharing	ICT for transforming project experiences into corporate assets. Object repositories. IPR protection of complex shared data. Context aware applications.
ICT enabled business models	New ways for sustainable exploitation of ICT as a key part of business strategy in the open European / global construction marketplace.

## Developing Roadmaps

When developing roadmaps, it is essential to consider radical innovation as the means to transform from the current state (as-is) to the vision (to-be). At the same time, it needs to be understood that to achieve the vision, incremental innovation is required. This serves as the basis for migration from a current state to short, then medium, and finally long in terms of time to industry.

Once the current state and vision are established, the next step is to identify the key business driver for change in the short term (time to industry). Based on this, key elements/actions to be achieved in the short term are identified and defined. Using short term elements/actions of the roadmap as the baseline this time, the business driver for incremental change is identified and based upon this, key elements/actions to be achieved in the medium term identified and defined. In a similar fashion, the driver for change from medium to long term and supporting elements/actions are identified.

The visual representation of a typical roadmap is illustrated in Figure 3 and the content structure shown in Table 2. It should be clearly noted that a roadmap (e.g. the one in Figure 3) is a snapshot at a given moment in time. This can be understood as follows:

- Current state: what is available and in use in the industry today
- Short time to industry: what is near ready for take-up and use by industry
- Medium time to industry: what is currently being developed
- Long time to industry: what is currently being researched or explored (emerging technologies)

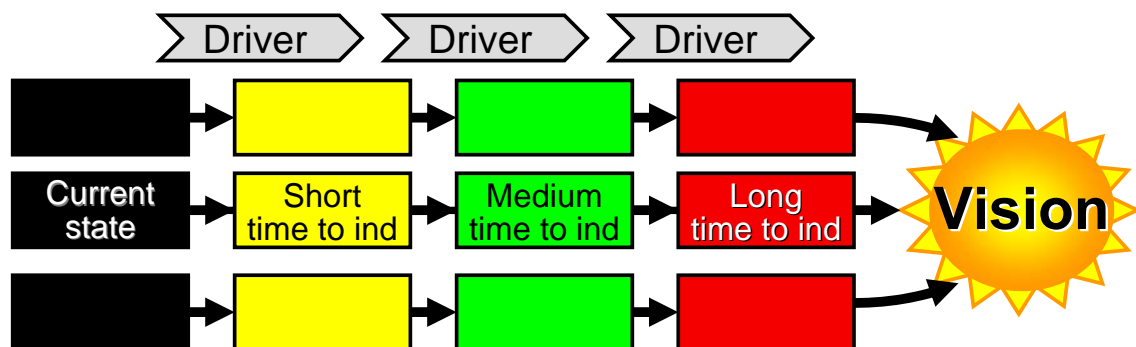


Figure 3: Visual Representation of a Typical Roadmap

Table 2: Content Structure of a Typical Roadmap

Background	<i>Industrial context and current state.</i>
Vision	
Target State	<i>The to-be state as foreseen by the vision.</i>
Business Scenario(s)	<i>Some possible business scenarios once the vision is achieved.</i>
Roadmap	
Objectives	<i>Main objectives of the roadmap in terms of achieving key priorities</i>
Main Research Areas	<i>Illustration of the roadmap and key research topics</i>
Current State of the Art	<i>Description of the current state of the art</i>
Time to Industry: Short term	<i>Description of elements for short time to industry</i>
Time to Industry: Medium term	<i>Description of elements for medium time to industry</i>
Time to Industry: Long term	<i>Description of elements for long time to industry</i>
Business Impacts	<i>Foreseen business impacts upon realisation of the vision</i>
Resources for more Information	<i>Thematic mappings to other related initiatives</i>



## Identifying Strategic Implementation Actions

Once the roadmaps have been finalised, the next step is the identification of strategic implementation actions (building blocks for projects). These actions may cover one element (e.g. one yellow box) of a given roadmap or span several elements, or even span more than one roadmap where relevant.

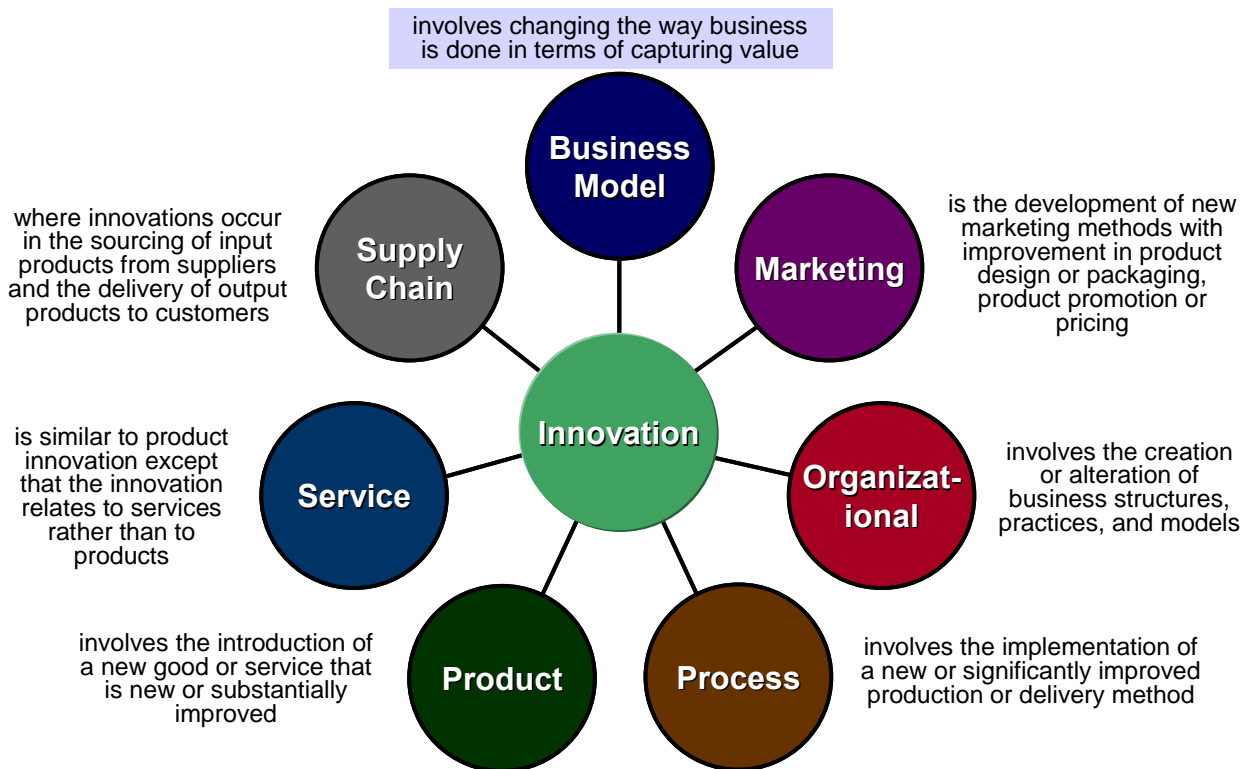
The template used with Strat-Con for strategic implementation action definition is shown in Table 3. This template was purposely structured to ensure that each strategic implementation action was captured on no more than one page.

**Table 3: Strategic Implementation Action Definition Template**

<b>Title</b> (max 10 words)							
<b>Keywords</b> (max 5)							
<b>Time to industry</b>		Short term		Medium term		Long term	
<b>Topic area</b>	Process :	1. Value-driven business processes				2. Industrialised production	
	Product :	3. Digital models				4. Intelligent constructions	
	Project :	5. Interoperability				6. Collaboration support	
	Enterprise :	7. Knowledge sharing				8. ICT enabled business models	
	Other :						
<b>Industrial problem / relevance</b> (Why is this action important? What are the main business drivers?)							
<b>Technological objectives</b> (What is the aimed measurable achievement / RTD innovation / progress beyond the state of the art?)							
<b>Approach</b> (How will the problem be solved: baseline technology + methodology / approach + necessary competencies?)							
<b>Results</b> (What tangible, applications / tools, methods etc. will be developed / extended?)							
<b>Exploitation</b> (How will the results be provided to users? Who will use the results and how?)							
<b>Impacts</b> (What potential benefits will follow from the use of results?)							
<b>Follow-up actions</b> (What else is required to achieve the benefits?)							
<b>Contact information of the proposer</b>							
<b>Name</b> (First, Last)							
<b>Organisation</b>							
<b>Email</b>							

## Perspectives of Innovation

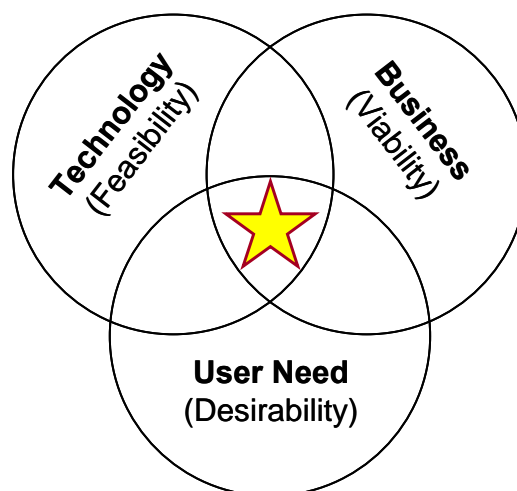
When developing the roadmaps and in particular the strategic implementation actions, different views to innovation were considered within Strat-CON. These included business, marketing, organisational, process, product, service, and supply chain perspectives as shown in Figure 4.



**Figure 4: Innovation Wikipedified**

(Source with modifications: <http://en.wikipedia.org/wiki/Innovation>)

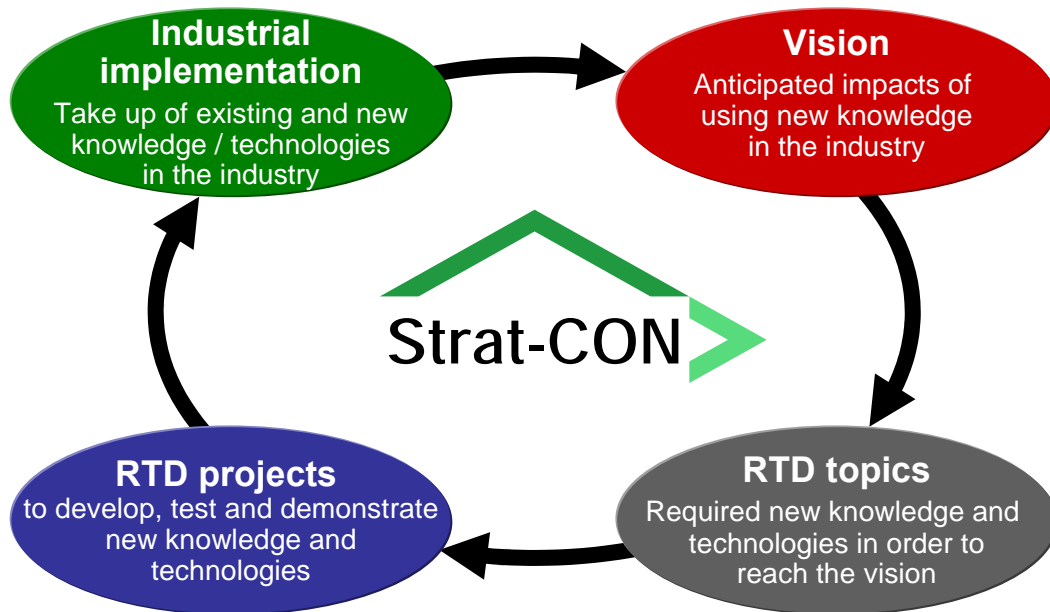
It is essential to understand that to lead to radical transformation of an industrial sector such as construction, it is necessary to both understand and address where innovation makes sense (see: Figure 5). Within Strat-CON, this was addressed through the roadmap elements defining technology feasibility, business scenarios demonstrating business viability, and both key business drivers, and time to industry perspectives acting as levers for satisfaction of user needs (desirability).



**Figure 5: Where and When Innovation Makes Sense**

(Source with modifications: *National Agency for Enterprise & Construction, Denmark*)

The innovation model used in Strat-CON is illustrated in Figure 6. The vision sets the foresight goal for industrial transformation through use of new knowledge and technologies. A set of RTD (research, technology, and development) topics are identified that serve as identification and definition of the required new knowledge and technologies required to achieve the vision. These topics need to be researched, developed, tested, and demonstrated through inter-related RTD projects. The results from these RTD projects then act as baselines for industrial implementation in the form of take-up and use of existing and new knowledge and solutions. These in turn contribute to achievement of the existing vision, and furthermore definition of a new vision.



**Figure 6: Closing the Innovation Loop: From Vision to Industrial Implementation**

## Roadmap: Value Driven Business Processes

<b>Main Business Drivers:</b>	performance-driven process, value to customer, total life-cycle support, product and service customisation
<b>Key Research Topics:</b>	performance-driven processes, process orchestration, metrics, indicators, requirements engineering, mass customisation

### Background

Nowadays, actors involved in the construction processes are facing the increasing complexity of projects (e.g. shorter delays, increasing number of actors involved in the design process, high quality requirements, variety of technologies, etc). The one-of-a-kind nature of construction projects adds to this great complexity.

Some relevant characteristics of the construction sector can be summarised as:

- Business processes and competition based on lowest project cost and short term antagonistic relationships rather than knowledge.
- Poor understanding and missing methodologies to assess and change value measurement, incentive drivers and contractual conditions.
- Production processes dominated by on-site labour and low productivity off-site production.
- Low level of product differentiation making companies vulnerable to increasing cross-border trade.
- Customer requirements not necessarily satisfied. Project delivery is based on cost and time optimisation, and not necessarily value to customer.
- Contracts typically awarded to lowest bidder and not necessarily best “performer”.
- Product/service customisation is limited and few opportunities exist for product/service re-configuration during product lifecycle.

Client demand for value-adding products/services, customisation, re-configurability, etc. are posing new challenges for contractors. There is a clear paradigm shift towards performance-driven process, value to customer, total life-cycle support, product and service customisation.

### Vision

#### Target State

The vision proposed in this roadmap is based on the fact that today, there are no tangible methodologies, models and tools available to manage performance and business processes in construction. It is advocated that to move from the current state of time and cost driven process towards value driven processes, performance driven processes, value to customer, total life cycle support, and product and service customisation must be supported.

Such a vision also leads to the following considerations:

- Strong stakeholders, like clients, are important agents of change and may provide leadership in the development of a sustainable built environment provided by an integrated supply side.
- Business relationships are based on trust, partnerships and win-win.
- The demands of end-users and society are met while optimising the use of resources; the technology available to achieve sustainable development is integrated in a systematic way, and the

integration is site-specific thereby exercising vigilance and meeting local expectations of end-users and achieving performance and 0-accident and health risks.

- The procurement of services or products is done in ways that improve responsibility, reliability, quality, encourage competition and stimulate innovation.

## **Business Scenario: Performance based Contracting and Conformance to Customer Requirements**

Shift of focus is needed; construction service providers have to see themselves as a short but regularly recurring chain of the client's business processes. The companies should be able to provide space for the customer in its entirety; helping client to define the needs, creating the performance brief based on those needs, designing the building, constructing, maintaining and operating it and finally, demolishing it. Performance approach forces the clients to think what is really needed to support their business processes. Performance based requirements give designers and suppliers possibilities to fully exploit their knowledge accomplishing creative and flexible solutions. When requirements are performance based, the variety of procurement methods is larger. The contractors can improve design and also benefit from this. Feedback from other parts of the process enables learning and better buildings in the future. In the future, contracts will be awarded based on the past performance of contractors and/or their potential in terms of performance to deliver a product/service as per customer requirements.

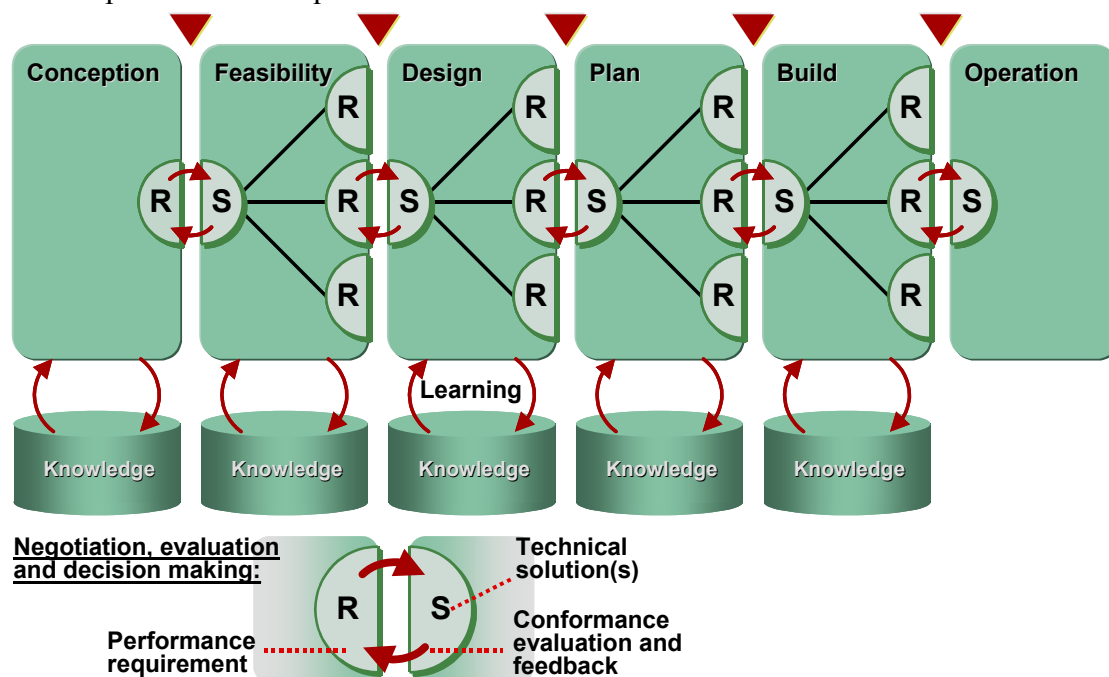


Figure 7: Conformance to Customer Requirements

## **Business Scenario: On-demand Customisation of Products and Services**

Clients require customised products and services that address changing client product/service needs during the lifecycle of the solution (product/service). Modular product and service design alongside mass customisation tools allow this to happen. Rather than select the closest solution available, clients will be able to “pick-and-mix” different product/service modules to design their solutions. As the product/service components will be modular in nature, they will not only be easy to design (modular design), but to also easily manufacture and assemble (industrial production). Once the product/service has served its purpose, rather than being demolished/terminated, and it could be easily disassembled, reconfigured, and re-used.

## Roadmap

### Objectives

The objectives of the roadmap are to develop an extended approach for Construction re-engineering, revisiting process-chains for conception, achievement, maintenance & restoration of buildings and infrastructures. This re-engineering should rely on knowledge-based paradigms and assessment metrics and methods, related to *value-/performance- driven business models* which can create incentives for better performance, innovation and knowledge creation, and it should include a systematisation of the value analysis over the life-cycle, from inception and design to exploitation and maintenance. This roadmap aims to address four main business drivers:

- Performance-driven process
- Value to customer
- Total lifecycle support
- Product and service customisation

### Main Research Areas

ICT should allow dealing with customer-centric definition of products and services, management of requirements being instrumental in providing what the end users want (especially how functional requirements are translated into design and production requirements), support for capturing and fulfilling predefined performance criteria. ICT should also support scheduling & planning with information transfer between applications used in different stages of the construction process. The following roadmap illustrates the main research areas for value driven processes. A set of short, medium, and long-time to industry research areas are identified for performance-driven process, value to customer, total lifecycle support, and product and service customisation respectively.

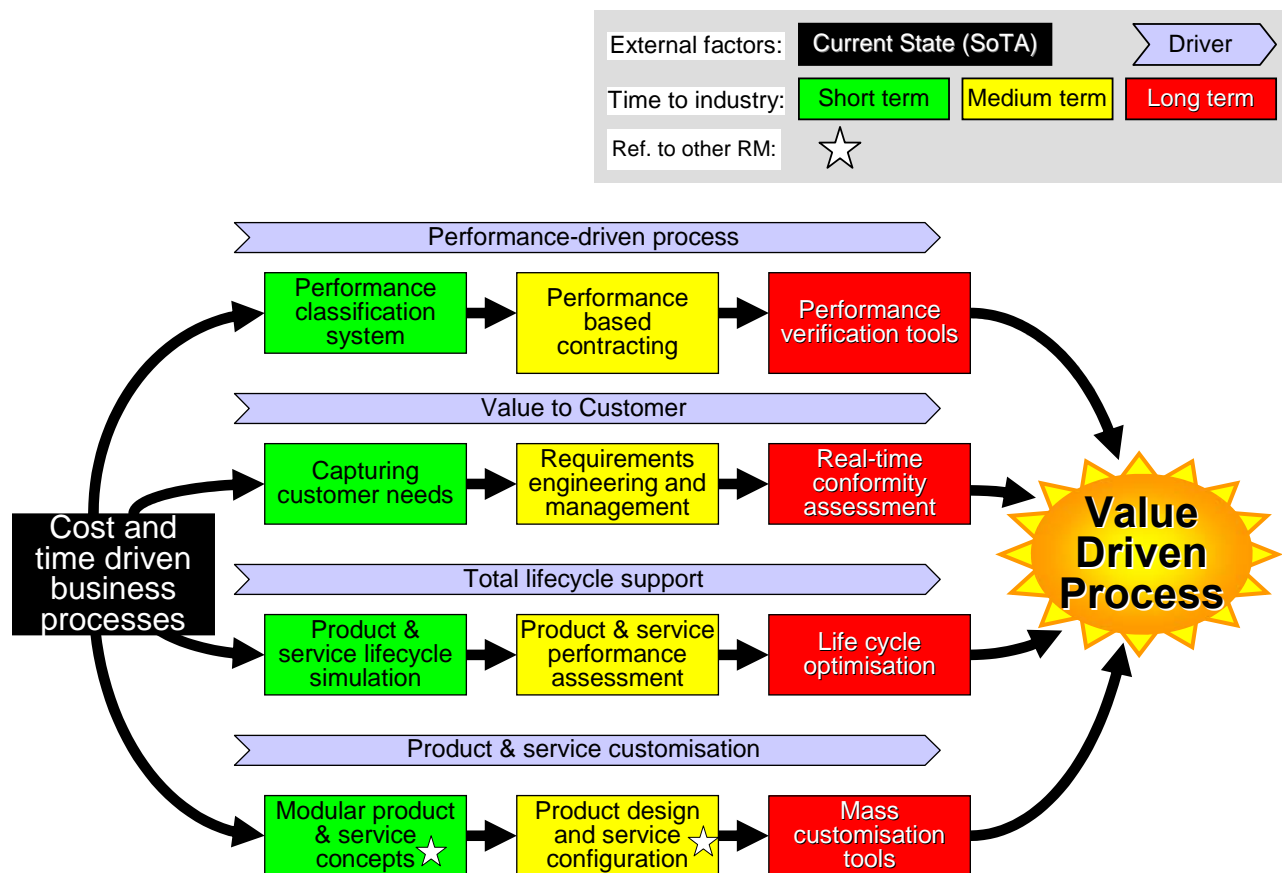


Figure 8: Roadmap for Value Driven Business Processes

**Short term:**

- Development of performance classification systems
- Methods for capturing customer needs in “tangible” form (e.g these requirements could be based on product/process performance)
- Methods, models and tools for product and service lifecycle simulation
- Development and use of modular product and service concepts

**Medium term:**

- Tools to support performance based procurement and contracting.
- Tools for the engineering and management of customer requirements
- Tools for product and service performance assessment
- Tools for customised product design and service configuration

**Long term:**

- Model based tools for performance verification
- Tools for real-time conformity assessment of customer needs
- Tools for product/service lifecycle optimisation
- Tools for mass customisation of products and services

**Current State of the Art**

- Cost and time driven business processes: Most business processes within the construction sector are built around the premises of minimisation of cost of production and time of product delivery. They may provide some economical benefits to the client and contractor, but this may be at the cost of non-satisfaction of initial client requirements, and furthermore the quality of the product/service may be compromised.

**Time to Industry: Short term**

- Performance classification system: A performance classification systems not only serves as an instrument to measure contractor/supplier and or desired product performance, but also serves as a common language through which different actors in the construction sector can understand each other.
- Capturing customer needs: Capturing customer needs and targets at the very beginning of the project is essential for a successful end result. It is also important to bridge the gap between customer terminology (satisfactory lighting in the office rooms) and the domain terminology (750 lux in the working area, no glare, even distribution of light). It is of paramount importance to ensure that the customer needs are captured in a tangible form that is then easily understood both by the customer and the product/service provider.
- Product and service lifecycle simulation: There is a need for tools that not only assist in the design and visualisation of products/services, but also provide a means to assess their respective lifecycles. As an example, how will the foundation of a building react to varying loads (e.g. initially an office building and then converted to a supermarket) over a period of twenty years when.
- Modular product and service concepts: Shorter delivery times are needed so that the structures of the built environment can adapt to the more rapidly changing business environment. Also more reliable and well-performing solutions are necessary. Modular product concept enables variety of end results from a limited number of modules that are effective to realise and easy to maintain. Tools for modular product and service design are essentially model-based and rely in



part on object orientation concepts. These modules in fact can be seen as plug-in, self-design, and operate.

### Time to Industry: Medium term

- Performance based contracting: There is a need for tools and services that allow analysis of past performance of contractors and suppliers and their competence from a performance based potential for future projects. Performance here is seen as being in conformance to the desired performance (value) of a product or service. Contracts are awarded on the basis of performance and not necessarily lowest bid.
- Requirements engineering and management: Too often the original requirements are lost due to the deficient requirements management. It is important to capture the client requirements at the beginning of the project, but it is equally important to manage the changes, and maintain transparent decision making during the performance driven process.
- Product and service performance assessment: Tools and services that provide the opportunity for regular product/service assessment. Though initially products and service lifecycles may have been visualised and simulated during design and/or construction stages (refer to product and service lifecycle simulation), there is a need for regular product/service assessment once these products (e.g. building or building component) are in use.
- Product design and service configuration: Relying on modular product and service concepts, there is a need for tools that support modular product design and service configuration. These tools will support the “drag-and-drop” of different product/service modules to form and mainly design a complete product or service. As such, the modules will in addition to geometric and material properties also contain behavioural and design information allowing for the design of the interfaces (connections) between different product/service modules.

### Time to Industry: Long term

- Performance verification tools: The verification of the performance requirements has to be regular. In all phases of the performance driven process, the technical solutions are (automatically) verified against the set performance requirements ensuring there are no defects in the final product.
- Real-time conformity assessment: There is a need for tools that allow for continuous verification of conformity to customer requirements. As is known in the construction sector, such requirements may change from one product/service lifecycle stage to the next. The tools will during each lifecycle stage support feedback from the designed, developed, or used product/service solution to the customer requirements.
- Life cycle optimisation: To ensure optimal use and minimal environmental impact (e.g. due to demolition, emissions from heating, air-conditioning, etc.), there is a need for tools and services that support product/service lifecycle optimisation. Lifecycle optimisation tools will support the efficient use of products/services both during and beyond their initial intended lifespan. They will not only provide better value to the customer through more efficient use of the product/service, but also contribute to minimising environmental impacts from the use of the building/service.
- Mass customisation tools: Customers today, typically demand unique products/services. Relying on modular product and service design, customers will be able to receive the product/service that they desire through an assembly of a set of choice products/services. Furthermore, being modular in nature, the products/services will be designed to be changeable when desired as opposed to being built for life. Mass customisation tools support industrialised production and support modular product and service design, operation, and reconfiguration. As an example, when a building needs to serve a new need, it can be reconfigured to do so without having to necessarily demolish and rebuild it, or without massive and time consuming refurbishment.



## Business Impacts

There will be a paradigm shift in terms of product/service delivery from lowest investment cost to optimal value to and conformance of requirements of the customer. Both customers and contractors/suppliers will share a common terminology (or interfaces to a common terminology) allowing for better understanding and delivery of customer requirements. Aided by modular product and service design, not only will more solutions be available to customers, but it will be feasible for designers and mainly contractors to deliver them. The products/services of the future will be fully configurable at start and reconfigurable during the lifecycle of the product/service. This will allow for example in the case of a major hazard (e.g. earthquake) to convert an opera house to a fully functional hospital within a matter of days (2-3), and to then re-convert it back to an opera house thereafter. Buildings, infrastructures and urban achievements of the future will integrate all new constraints, including a rational use of energy, minimising risks, trouble and discomfort for the individual users, and minimising pollution and risks of any kinds for all users in general and the society.

## Thematic Mapping and Further Information

FP7 Information & Communication Technologies	<ul style="list-style-type: none"> <li>• ICT meeting societal challenges:               <ul style="list-style-type: none"> <li>– Health, environment &amp; sustainable development, risk &amp; emergency management, data management for environmental monitoring (contributing to INSPIRE, GMES, GEOSS).</li> </ul> </li> </ul>
FP7 Nanosciences, Nanotechnologies, Materials & new production technologies	<ul style="list-style-type: none"> <li>• Developing generic production assets (technologies, organisation, production facilities) meeting safety &amp; environmental requirements.</li> </ul>
FP7 Environment	<ul style="list-style-type: none"> <li>• Impact of buildings &amp; cities:               <ul style="list-style-type: none"> <li>– Identification of pollutions sources, emerging environmental stressors &amp; their potential health effects.</li> <li>– Sustainable management of the urban environment.</li> </ul> </li> </ul>
ROADCON 2003	<ul style="list-style-type: none"> <li>• Legal and contractual governance.</li> <li>• Performance driven process.</li> <li>• Total Life Cycle support.</li> </ul>
ELSEWISE 1997	<ul style="list-style-type: none"> <li>• Awareness of technological opportunities.</li> <li>• Functional requirements &amp; conformance assessment.</li> <li>• Decision support.</li> <li>• Demanding client.</li> </ul>
FIATECH 2007	Element 3: Integrated, Automated Procurement and Supply Network

## Roadmap: Industrialised Production

<b>Main Business Drivers:</b>	Supply network management; Open market; Effective manufacturing and construction.
<b>Key Research Topics:</b>	ICT support for modular provision of customised constructions; Logistics, on-site production and assembly; Integration of construction site in the process.

### Background

Industrialised production in construction means application of modern manufacturing methods in prefabrication, supply network management and on-site assembly. The underlying drivers are safety at work, productivity, time to delivery and predictable quality. Moving site production offsite requires radical shift of thinking construction as one-of-a-kind oriented craftsmanship towards construction as a knowledge based industry. Ad-hoc design and re-invention needs to be replaced by development of modular, re-usable solutions and customer oriented configuration management. Industrialisation will both require and benefit from an EU-wide open market for manufactured building components and services. The required ICT tools will support promotion of manufactured components in the market, customer oriented configuration design & management, effective supply logistics and on-site automated production and assembly.

### Vision

#### Target State

The vision of industrialised construction comprises:

- Construction sector offers safe and attractive high-technology work places.
- Sites, construction machinery and mobile staff are connected to corporate information networks.
- Customised construction products are produced industrially.
- Manufactured construction products are offered on the EU wide open market.

#### Business Scenario: Mass Customisation

This scenario combines industrialised production with individual design solutions: An essential part of design is done in advance before any specific construction project. The pre-defined solutions provide options for customised configurations for specific situations:

- Building concept is a generic definition of a building type and the range of its possible performances that address the needs of a market segment described in a way that allows conformance assessment. An example of a building concept is “low energy building”. Different providers may offer competing proprietary solutions a building concept.
- Product platform is a set of specific, possibly proprietary, re-usable technical solutions for configuring customer specific systems and buildings (layouts, components, modules, connections).

Many building components are available as manufactured components with some degree of customisation. Manufacturers provide information about their products in the web-based intelligent component catalogues which describe relevant data for product selection and customisation. The required design logic and guidance is embedded in the component objects.

Users, e.g. designers, search the web for products that meet specific criteria. Standardised classification schemes and product attributes enable EU-wide access to product information. Selected objects are incorporated to the designers’ CAD system by dragging and dropping. Each object is adapted to

its environment and function based on its built-in design logic. For instance, a beam can adopt itself to the specific span width and load.

A similar approach is applied on the level of overall design: pre-made "template" designs for rooms, structural frames etc. are available, from internal development by companies or from specialised service providers. The overall design is composed from templates which are configured to fit as partial solutions within a unique overall solution.

### **Business Scenario: Ambient Manufacturing**

This scenario introduces manufacturing-level production methods in factory and on site.

- Factory production uses "normal" manufacturing methods which are adopted from other industries, e.g. FMS and robotics.
- Rapid on-site assembly methods make use of intelligent machinery, high-precision positioning, fast hardening connection materials, customised connection components produced with rapid prototyping technologies ("3D printing"), real-time digital site model which is accessible to site personnel via wearable terminals, etc.
- Special products are pre-assembled / pre-produced in small mobile factories at or close to site or during transport. Examples: ventilation ducts, HVAC-assemblies etc.

## **Roadmap**

### **Objectives**

Develop modular (intelligent & pluggable) products, integrated multifunctional modules and production equipment for industrialized off-site production and methods for rapid on-site assembly and connection. Develop innovative measurement techniques for assessment and quality control of materials in arrival at the construction site. Develop tools for effective logistics management from suppliers to site and ambient/embedded guidance for on-site assembly work.

A second objective, in the specific context of the Construction sector, is related to the operation of the Construction site where assembly of the Construction product is done. This objective is to develop a new approach integrating a generalized use of ambient technologies and semantic knowledge technologies to ensure optimisation of on-site manufacturing, integration, resource management and quality control:

- with secure access to site information to all involved stakeholders,
- while minimising "embodied energy" (which is the sum of all energies consumed for the construction - e.g. adequate production of materials), - and during the construction of the building or infrastructure),
- and ensuring "stealth Construction sites", especially in case of refurbishment or rehabilitation of existing legacies under strong functional, environmental and human constraints: this is to be achieved by low-intrusive renovation techniques with minor impact on public, directed to groups with special needs.

### **Main Research Areas**

The RTD targeting Industrialised Production is driven by two main trends:

- Evolving EU-wide open market in constructions.
- Increasing productivity throughout the supply network including the construction site.

#### **Short term:**

- Tools for supply network and logistics management.
- Flexible manufacturing.
- On-site communication.

### Medium term:

- Standards for supply network integration.
- Customer oriented configuration design & management using manufactured components.
- On site production and assembly methods.

### Long term:

- Customised product & service integration.
- Manufacturing level on-site production and information management.
- Fully virtual production.

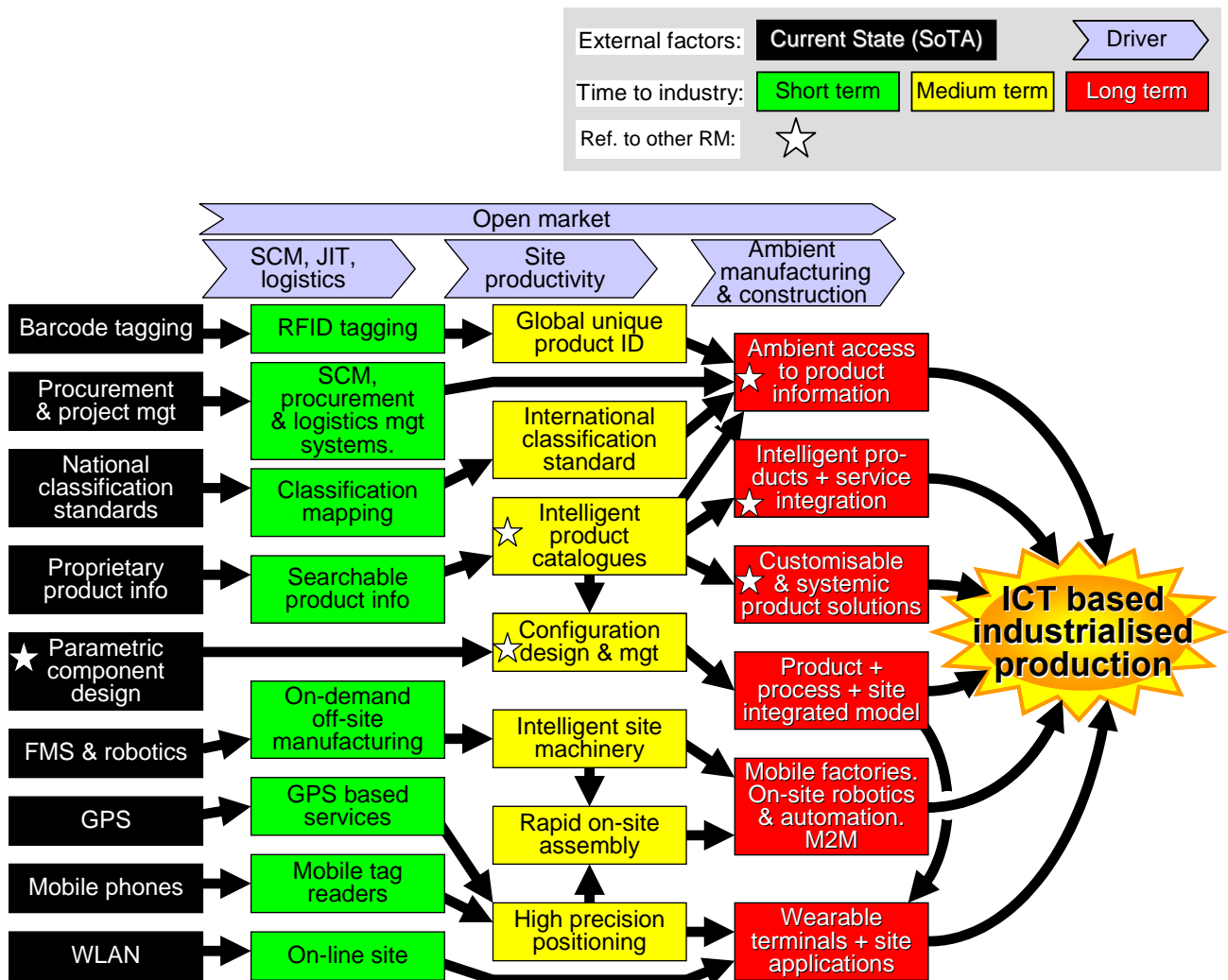


Figure 9: Roadmap for Industrialised Production

### Current State of the Art

- **Barcode tagging:** Products are tagged on a category basis. Individual instances of similar products are usually not differentiated. Custom made products are identified with supplier specific codes (human readable only). This limits possibilities for precise logistics management, assembly planning and monitoring over product life cycle.
- **Procurement:** Procurement is based on annual agreements between the buyer and a few preferred suppliers. This together with dominantly national classification standards limit possibilities for open procurement.

- Project management: All collaborating project partners use ICT-based project management tools but these are not integrated. Project management is largely a human centric activity with intensive personal communications. Web based access to a shared document server is also common but mainly used by office-based personnel only.
- Product information: Suppliers provide product information in proprietary formats with no or low semantics. This limits possibilities for finding the best fitting products and access to product specific information.
- Parametric component design: Manufactured components are often designed with parametric ICT-applications provided by the suppliers / manufacturers. Users and customers have limited access to such applications and need to engage in human centric sales negotiations.
- FMS & robotics: Industrialized construction is in many cases characterised by manual production in indoor conditions (“factories”). Adoption of effective manufacturing methods is limited e.g. FMS and robotics, JIT, Kaizen, lean production.
- Geographic positioning systems: GPS is already used for tracking logistics processes. High precision positioning is not available for on-site conditions, e.g. indoors and underground.
- Mobile phones: Mobile phones are commonly used by most personnel and suppliers, including SMEs, on- and offsite. SMS messaging is used for reporting receipt of deliveries and quality checks. Construction specific mobile productivity applications are rare.
- LAN/WLAN: Site offices are connected to the corporate ICT system of the main contractor. Wireless networks on constructions sites are increasing and provide access to corporate networks and the internet.

### Time to Industry: Short term

- RFID tagging, supply chain & logistic management: RFID tags allow wireless reading of product identification and access to product information. ICT applications are needed for component tracing throughout the delivery process.
- Web-based & mobile platforms for computer supported collaborative work (CSCW): Collaboration tools are already commonly used by office based personnel and need to be enhanced to serve mobile and site personnel, too.
- Classification mapping: Building classification systems are deeply rooted in national and regional process practices. A short term strategy in order to promote cross-regional trade is to provide mapping between different classifications.
- Searchable product information: The users often need to find suitable products for specific purposes. Product information is available from manufacturer’s / suppliers catalogues, that are increasingly published on the web. In order to support searching the web based product information should include standardised classification codes, keywords and property attributes.
- On-demand off-site manufacturing: Integration of communication capabilities and flexible manufacturing technologies allow responsive manufacturing of custom components at short notice.
- GPS based services: GPS positioning devices are commonly available and are useful for tracing products in logistics processes.
- Mobile tag readers: Mobile readers are readily available e.g. integrated with mobile phones. Combined with application software, GPS positioning and embedded digital cameras these devices can be used for versatile reporting purposes.
- On-line site model: Digital modelling of products is already common. Enhancing these models with scheduling information leads to “4D” models that are useful for communicating the pro-

gress on site. Such models can be made available to stakeholders via web, in addition to documents, digital photos and videos.

### **Time to Industry: Medium term**

- Global unique product identification: All products need to have global identifiers. It is not sufficient to identify the product category only – also the individual instances of similar products need to be identifiable.
- International classification standard: In order to enable fluent international trade of construction products a standardised classification system is needed and reflected in ICT tools for e-procurement and logistics management of manufactured components.
- Intelligent product catalogues: Technologies like semantic web enable implementation of “intelligent” catalogues which are searchable, include embedded knowledge (e.g. design rules & instructions) and provide customised views to different users based on their needs. Exploiting these opportunities needs to be aligned with the marketing strategies of suppliers and manufacturers.
- Configuration design and management: Buildings are individually designed as one-of-a-kind products. Increasing industrialisation leads to platform-based, customisable systemic solutions for construction products and services. Configuration design and management tools are needed for customisation.
- Intelligent site machinery: On-line connectivity of site machinery for monitoring of capacity utilisation and condition, maintenance needs etc.
- Rapid on-site assembly: Increasing off-site production necessitates just-in-time deliveries, elimination of storage on-site and rapid assembly methods. Efficient site operations need to be supported by enhanced planning and monitoring.
- High precision positioning: High precision measurement and positioning methods are needed to support assembly of manufactured components.

### **Time to Industry: Long term**

- Ambient access to product information: Widely accessible communication infrastructures and embedded intelligence (identifier tags and sensors) allow ambient access to published product information as well as real time product status anywhere anytime.
- Intelligent products + service integration: Embedded sensors and intelligence in products support related services like remote control, condition monitoring and maintenance.
- Customisable & systemic product solutions: Self-configuring intelligent products adopt themselves to new usage scenarios and system solutions.
- Product + process + site integrated model: All production related information will be modelled.
- Mobile factories, on-site robotics & automation, M2M: Construction sites make use of manufacturing level production methods like robotics and automated and remotely controlled machinery. Flexible production is distributed in factories, on-site and mobile production cells (“mobile factories”).
- Wearable terminals + site applications: Mobile terminals hosting various context & location aware applications are integrated in the apparel of site personnel.

## **Business Impacts**

The solutions shall radically improve safety at working place and offer attractive knowledge intensive employment opportunities and shall also address retrofitting.

Construction sites will be safer, better organised (and therefore less expensive) and optimising refurbishment, while at the same answering to a strong societal demand of minimising discomfort of people living around, or being customers of the building or infrastructure.

## Thematic Mapping and Further Information

FP7 Information & Communication Technologies	<ul style="list-style-type: none"> <li>• ICT supporting business &amp; industry: <ul style="list-style-type: none"> <li>– <i>Manufacturing</i>: rapid and adaptive design, production and delivery of highly customised goods; digital and virtual production; modelling, simulation and presentation tools; miniature and integrated ICT products;</li> </ul> </li> </ul>
FP7 Nanosciences, Nanotechnologies, Materials & new production technologies	<ul style="list-style-type: none"> <li>• Developing generic production assets (technologies, organisation, production facilities) meeting safety &amp; environmental requirements. <ul style="list-style-type: none"> <li>– <i>Materials</i></li> <li>– <i>New production</i>: development and validation of new industrial models and strategies; adaptive production systems; networked production; rapid manufacturing concepts for small series industrial production.</li> <li>– <i>Integration of technologies for industrial applications</i>: Sectoral applications e.g. in construction.</li> </ul> </li> </ul>
FP7 Environment	<ul style="list-style-type: none"> <li>• Technologies for managing resources or treating pollution (e.g. on Construction sites) more efficiently.</li> </ul>
ROADCON 2003	<ul style="list-style-type: none"> <li>• Digital Site.</li> <li>• Ambient access.</li> </ul>
ELSEWISE 1997	<ul style="list-style-type: none"> <li>• Manufacturers' product catalogues.</li> <li>• On-line site</li> <li>• Process models.</li> </ul>
FIATECH 2007	Element 4: Intelligent & Automated Construction Job Site



## Roadmap: Digital Models

<b>Main Business Drivers:</b>	semantics and interoperability => user and lifecycle orientation => real-time adaptive models.
<b>Key Research Topics:</b>	nD models, access to life time information for all stakeholders anywhere anytime; ICT for design, configuration, analysis, simulation, and visualisation.

### Background

Electronic business activity is less developed in the construction industry than in manufacturing sectors. There are a multitude of standards, technical specifications, labels, and certification marks. Electronic business activity in construction is very limited compared to the other sectors studied by e-Business W@tch. Many companies prefer to be re-active rather than pro-active in their use of ICT. The construction industry has yet to show the same level of ICT driven improvement of productivity as in other industries. This can partly be explained by the nature of the work and the type of production involved in construction processes. It is also related to slow uptake of ICT in a sector which is dominated by SMEs. Large enterprises in the industry and new sector entrants have adopted ICT based production methods. However, there is still great potential for further ICT uptake, for example: production planning systems, ERP-systems with financial components, inventory management systems, supply chain management (SCM) and mobile solutions. Business process integration may be a key driver for ICT adoption in the future. Most companies in the sector tend to organise work around individual construction projects which has led to a fragmentation in ICT use and e-business activity, characterised by a lack of commonly accepted standards, technical specifications and labels. (Source: e-Business Sector Studies – Construction, <http://www.ebusiness-watch.org/resources/construction/construction.htm>)

The current situation can be summarized as follows:

- Current ICT tools in the construction industry are based mainly on application-specific data or are at low semantic level such as (digital) 2D-drawings and textual specifications. This hampers automation and integration of processes.
- Semantic "nD" modelling is increasingly supported by proprietary software tools and interoperability standards.
- Sharing semantic data is hampered by insufficient protection of intellectual property.
- Products are designed and delivered to order, with low degree of configurable manufactured components.
- Current constructions are mainly "dumb", poorly documented and difficult to use in an optimised way, while becoming increasingly complex due to use of new technologies.
- Existing intelligent (sub)systems and tools are poorly integrated.
- Exchange of geometry is manageable, but further related information ("intelligence") has to be recreated.



## Vision

### Target State

The vision of future digital models in the Construction Industry is as follows:

- All systems in constructions share common platform, network and protocols, with secure external connectivity via the internet enabling local, remote and mobile monitoring, diagnostics, reporting and operation.
- These systems provide optimised control and intelligent services to users and operators.
- The life cycle of construction products is supported by applications using semantically rich models that contain all relevant information without need for human interpretation.
- Digital models are accessible anywhere and anytime.
- Future digital models providing easy access.

### Business Scenario: The Annotated "Planners"- Knowledge Base

Architectural practice shows frequently a high fluctuation in terms of the average duration of employment and this within miscellaneous planning offices. Especially team-members and -partners are changing during the repeatedly drawn-out planning process. A fact that leads to a loss of knowledge in cohesive planning processes and in understanding previous working steps. Short-term employment therefore leads to a high risk of direct loss of accumulated knowledge. It has furthermore to be considered that it is hard for new employees to orient themselves in an ongoing project and to take over the assigned planning tasks. How can novice employees orient themselves in a complex planning process? Is there a way of directly reading into the past activities? Therefore a knowledge base is to be developed minimising that specific knowledge loss. The vision is to create a digital data model environment, which at the same time allows the user to access additional knowledge about the planning-status and annotated information of a diverse planning content. Structured information has to be collected in during the process of planning and directly linked with the digital model. It is urgent to create an easy access for new employees for getting in touch with the far reaching information of complex planning. The structure of this model basement has to be quickly readable and allows for uncomplicated learning. Using the annotated *Planners Knowledge Base* will minimise the loss of specific planning-knowledge and open the gateway to an easy accessible working platform for novice employees.

### Business Scenario: The Easily Accessible "Virtual Building Model"

Normally, enormous amounts of 2D-representations of a (future) building are constituting the planning basis for managing the construction-site and later on the conservation of the building during the whole lifecycle. Understanding and relating different sources of 2D-information is a complex task, inactively and usually connected with the problem of spatial representations in case of complex geometry. Instead of collecting loosely coupled 2D-documents with a high demand for "correct" human interpretation, the "Virtual Building Model" is offering a database driven model (combination with a structured project database). One of the features of the "Virtual Building Model" is the generation of representations on demand. Offering such a set of features means setting up the foundations for a complex 3D-model at an early stage of design. Necessarily the digital model receives continuous refinement. During the ongoing planning process the digital model gets more and more detailed. Subject to the user, specific information is opened on different levels to the diverse planning partners. Access-keys are allowing to implement and change 3D-information subject to declared points of time. The 3D-model contains any collected relevant information about the real-scale building. After finishing the construction work it serves as an easily accessible 3D-representation of the 1:1 building providing efficient conservation and monitoring data.

## **Business Scenario: Building Information Models on Digital Maps**

The use of online map services is now gaining wide usage by both individuals and corporations. However, in many cases the accessible information is limited to geographical coordinates and images of e.g. buildings. This scenario builds upon providing access to a given building (or infrastructure element's) relevant information through a building information model. Buildings are no longer seen as static pictures or geographical coordinates, but as digital information rich models of the building. They can provide on demand (and upon authentication) information on the type of material used within the building, relevant dimensions of rooms, doors, windows, etc. This should actively support facilities management firms in supporting and actively monitoring all the buildings that they are managing within a given geographical space (neighbourhood, city, or even country). Furthermore, based on the information provided through a building's information model, user could be able to identify relevant service providers within the vicinity of the building for a given service or to for example acquire a particular component. For example, when a user needs to replace a particular door, then based on the information from the building's information model, the user should be able to search for vendors nearby with a capability to provide replacement doors.

## **Roadmap**

### **Objectives**

Generalise the development of translators and interfaces between applications and standard data presentations (e.g. IFC), object databases (e.g. product / component libraries) and Model servers for sharing product model data, and models and ontologies to cope with any levels of semantics. Research should be pursued on the fields of:

- Model mappings & generalized ontology interoperability;
- increased intelligence of applications and interfaces for communication with other applications;
- Extensible models through metamodels enabling flexible extensions to standard models based on specific needs not covered by the standards;
- Model checking for validating model data against standards, regulations, design rules, contracts etc., with possible notification of identified conflicts and, when possible, suggesting corrective measures.

Models are key underlying assets for shared information between architecture and engineering based on simulations and visualisations:

- *Performance Simulation*: generalise and deploy the use of “single-simulation” tools (structural, lighting, thermal, acoustics, safety, schedules, construction tools, etc.) for engineering and construction processes, moreover with integration of these simulation tools with other Lifecycle tools;
- *Visual Simulation*: 3D visualisation of the geometry of the building and real-time “walk-throughs” allowing to inspect the building from the inside and to visualize its integration in the neighbourhood, 4D simulations (4D is 3D geometry added by time information enabling e.g. simulation of assembly process on site), interference checking, etc.
- *Generation of manufacturing information on demand*. Accessing Rapid prototyping, CNC and Computer aided manufacturing.

### **Main Research Areas**

ICT should support scheduling & planning with information transfer between applications used in different stages of the construction process.

#### **Short term:**

- Take up of existing process paradigms: performance based procurement, open building etc.
- Development and standardisation of value metrics and indicators.

### Medium term:

- Methods and tools for capturing value requirements, and transforming and validating them between stakeholders throughout the process.
- Re-engineering business processes for dynamic supply networks, driven by customer-perceived value and sustainability.
- Models and tools for performance-based contracting, customer involvement, partnering and system integration.

### Long term:

- Integrated theory and related methodologies for modelling and rapid engineering of dynamic project-based business processes and networks.
- Configuration tools for consortium formation, contract preparation and ICT integration.

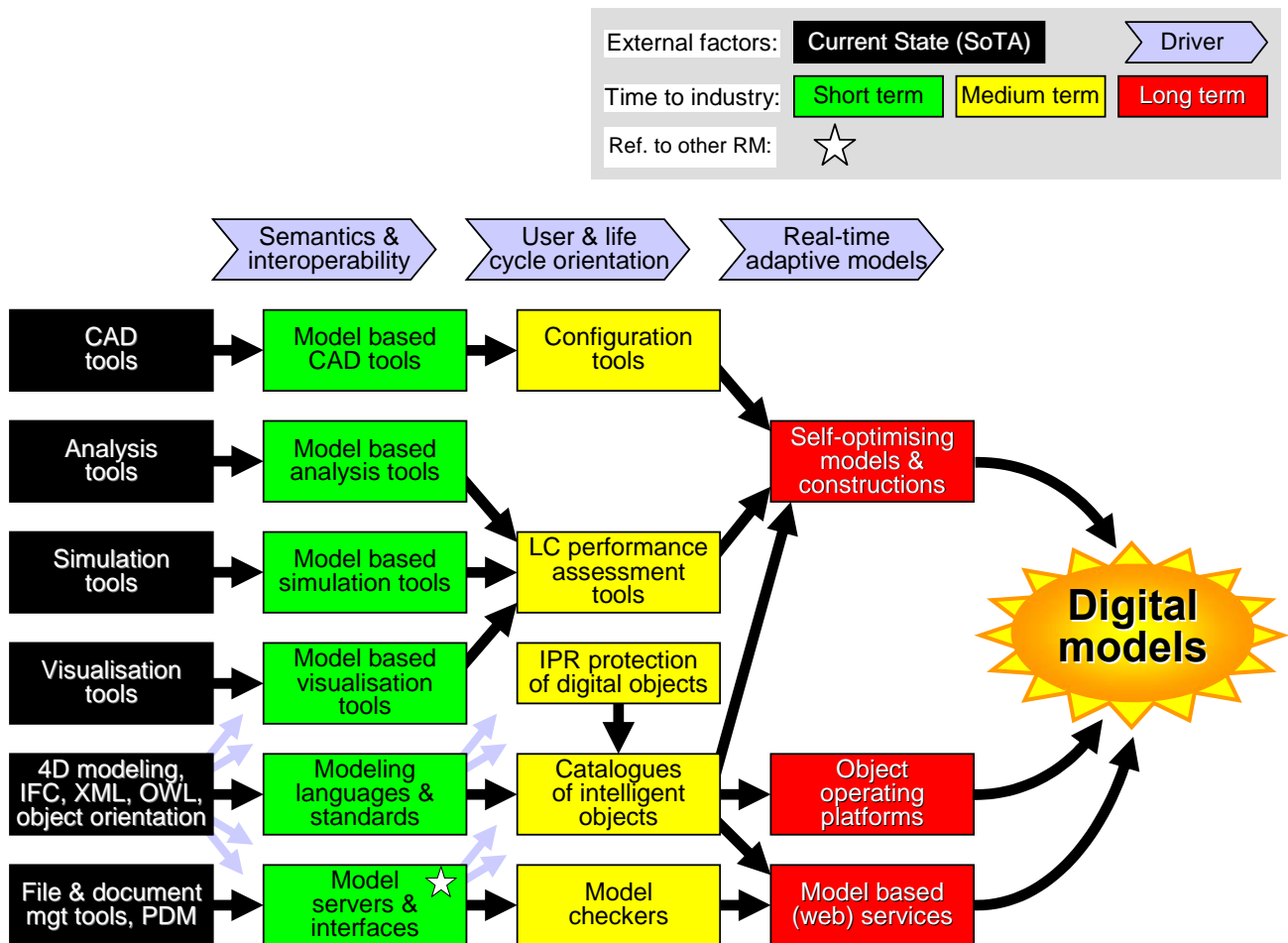


Figure 10: Roadmap for Digital Models

### Current State of the Art

- CAD-tools: Different packages serve the professionals with a varying set of (dis-)advantages. Basic visualization tools are incorporated.
- Analysis and simulation Tools: In some cases to be regarded as “stand-alone tools”, partly highly specialised; only covering a smaller part of a range.
- Visualisation tools: By means of imported modelling data further processing can follow, such as advanced texture mapping leading to high end visualization (photorealism, ray tracing) and animation.

- 4D- Modelling: linking of 3D (CAD) geometry to one or more schedule activities. Tools for project organisers and project team members to better communicate and analyze schedule information.
- File + Document mgt tools: System mainly used for exchanging and storing files (documents).

### Time to Industry: Short Term

- Model based CAD tools: Fading away from plain (digital) 2D-drawings and isolated textual specifications towards a higher semantic level of building information, database driven model basis.
- Model based analysis tools: Effective reuse of already created CAD-geometry, possibly as plug-in or add-on (eventually within the CAD-environment); intuitive handling supported and less education required, leading faster to valuable results.
- Model based simulation tools: Effective reuse of existing CAD-geometry. Possibly as plug-in or add-on (eventually within the CAD-environment); intuitive handling supported and less education required, leading faster to valuable results.
- Model based visualisation tools: Improved (re-) use of existing geometrical data for representation issues, minimal conversion work and subsequent post-editing efforts.
- Modelling languages & standards: Efficient handling of variety with avoidance of repeated loss of information; uncomplicated implementation of well-functioning conversion tools and coherent standards.
- Model servers & interfaces: Support of collaborative working attitudes; handling without delaying synchronization issues; viable solutions for the maintenance of versioning aspects.

### Time to Industry: Medium Term

- Configuration tools: Tools for customer-centric holistic definition, configuration and optimisation of products. User friendly interfaces with visualisation, augmented/virtual reality, context- and location-awareness, to support communication and decision making by stakeholders. Progressive use of pre-modelled building parts/components and subsequent assemblage.
- LC performance assessment tools: Semantic based ICT tools for various engineering applications of different actors at all life cycle stages. Tools for assessment and simulation of product life cycle performance: aesthetics, comfort, costs, energy usage, environmental impacts, flexibility, functionality, serviceability etc. Integration of simulation, visualisation and analysis tools, allowing for the assessment of the expected performance.
- IPR protection of digital objectives: Clarified legal handling when using/accessing object catalogues.
- Catalogues of intelligent objects: Object catalogues of products, services etc. supporting e-commerce of manufactured products and specialized services.
- Model checkers: Automation of control and verification of formal specifications. Compliance with specified computational modelling rules. Checking consistency of data entered (conflicts, collisions, ...). Indication of changes to underlying data (for example: imported geometry) before and after feature recognition.

### Time to Industry: Long Term

- Self optimising models & constructions: As ongoing planning and building execution work may cause changes and alteration, consequences in all directions should be controlled. Handling of contextual information; responsiveness to changes occurred by iterative design processes.
- Object operating platforms: Distributed computing, including a delivery of interactive services, without limitation accessible by all stakeholders.

- **Model based (web)-services:** In a complex web-based system a model can be used as unifying framework in which each component finds its place. Therefore a distributed ICT infrastructure is needed. Using model servers enabling sharing of information at high semantic level by all stakeholders throughout product life time and including open access to information of built environment and cultural heritage. Furthermore the protection of intellectual property in digital object models has to be ensured.

## Business Impacts

Pervasive use of ICT-based models will deeply improve quality control, assessment, monitoring and measurement of project progress and performance, especially based on the identification of quality repositories and performance indicators and standards, and will be the support for development of methodologies and procedures to effectively manage productivity and quality. It will allow the development and adoption of high sustainability standards (eco-labelling, certification, performance-based standards, etc.) related to protection of environment, saving of natural resources, health and safety, safety of workers, etc.. It is also a key instrument for:

- the adoption of a *product* total lifecycle approach, including all management aspects at various stages of the product lifecycle, including pre-construction, construction and post construction (e.g. development management, project management, resource management, design management, etc.).
- the improvement of the *process* efficiency and effectiveness (including feasibility, planning and scheduling of activities). This includes means to analyse and measure productivity, analyse risks, allocate resources, plan sites etc.).

## Thematic Mapping and Further Information

FP7 Information & Communication Technologies	<ul style="list-style-type: none"> <li>• Simulation, visualisation, interaction &amp; mixed reality.</li> </ul>
FP7 Energy	<ul style="list-style-type: none"> <li>• Smart energy networks.</li> <li>• Energy efficiency &amp; savings.</li> </ul>
ROADCON 2003	<ul style="list-style-type: none"> <li>• Collaboration support for distributed virtual teams.</li> <li>• Flexible interoperability.</li> <li>• Model-based ICT.</li> </ul>
ELSEWISE 1997	<ul style="list-style-type: none"> <li>• Decision support.</li> <li>• Internal &amp; external libraries.</li> <li>• Legacy applications.</li> <li>• New applications.</li> <li>• Object-oriented tools.</li> <li>• Product models.</li> <li>• Total life cycle management.</li> </ul>
FIATECH 2007	Element 2: Automated Design

## Roadmap: Intelligent Constructions

<b>Main Business Drivers:</b>	integrated automation and control (connectivity) => remote diagnostics and control (serviceability) => context-aware seamless configurability (adaptability)
<b>Key Research Topics:</b>	smart embedded systems & devices for monitoring and control, embedded learning & user support.

### Background

Intelligent Constructions and Smart Home Environments indeed correspond to needs already expressed in various other FAs of the ECTP. The current state is that of final constructions containing various and increasingly versatile control and service systems, which are not (or very few and in scarce cases) standardised, and not interconnected among themselves. Moreover, they are currently based on vendor-specific technologies using "dumb" devices, proprietary software platforms and wired connections and protocols. Monitoring, maintenance and services are done by specialised companies, each responsible of different systems, which are relying on customised ICT (to meet specific needs of users) and are based on monolithic applications that require manual configuration for specific uses, maintenance and support.

### Vision

#### Target State

*The vision proposed in this roadmap is that in the future, all objects<sup>3</sup> within the home, the office or potentially any building will communicate and provide information ubiquitously, and will be able to "understand" people circulating or living in the built environment so as to answer to their needs at any time.*

To achieve such a desired state, it is required that:

- ambient intelligence is kept and managed within chips, sensors, actuators,... embedded in objects that are able to dialog thanks to wireless communication techniques;
- all systems in constructions share common platform, network and protocols, with secure external connectivity via the internet enabling remote and mobile monitoring, diagnostics, operation and self-reporting, and provision of innovative interactive services to people at home or in their working environments.

Typical fields of applications of these R&D developments are for instance solutions related to Ambient Assisted Living (AAL), especially for disabled and ageing people, or in another field, Positive Energy Buildings (PEB - and also energy self sufficient buildings), with a new vision for tomorrow building energy performance to solve the huge global problem on sustainable energy uses at world-wide scale, with Europe having a leadership in this action.

Typically, this should be supported, among others, by technologies for ambient access<sup>4</sup> to all building information that should be made available to all stakeholders anytime and anywhere, and regardless of physical location: office, construction site, home, etc. ICT systems have to be intimately

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<sup>3</sup> including objects as simple ones as doors, windows, etc., potentially communicating with furniture like chairs, ovens...

<sup>4</sup> Ambient access stems from the convergence of 3 key technologies: 1) ubiquitous computing, 2) ubiquitous & secure communication, and 3) intelligent user-friendly interfaces.



integrated with everyday environments and supporting people in their activities or their daily life. Wireless and powerless sensors should support interactive spaces providing personalised, location and context aware services<sup>5</sup>, and in an ultimate visionary future of the “smart, self-configuring and self-adapting home / building”, users needs and requirements (including evolution of users’ profiling) will require special attention, based on advanced technology like pattern recognition and uncertain reasoning (e.g. fuzzy or probabilistic logic, or neural nets).

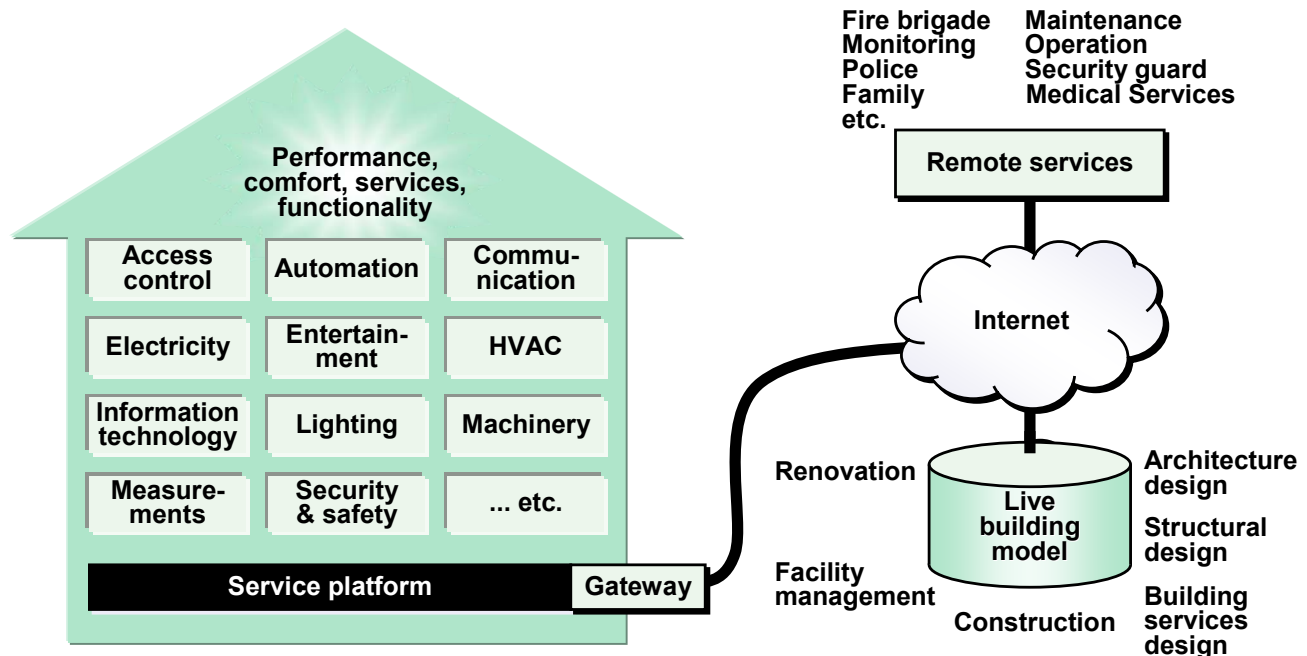


Figure 11: A Potential (non exhaustive) View on “Intelligent Constructions” Services

### Business Scenario: Ambient Assisted Living for the Elderly

This scenario springs from a societal objective to assist elderly people to remain in their familiar home surroundings, prolonging independent living and postponing their need to move into institutional care. Age is beginning to affect wider society in very challenging ways. According to the UN report World Population Ageing: 1950-2050, **ongoing demographic change is unprecedented** and profound. It may lead to a restructuring of Society “as social and economic forces compel us to find new ways of living, working and caring for one another”. Everybody will be affected – young or old – and it is likely that never again will societies be shaped demographically as in the past with more young than old. In 2002, the number of persons aged 60 years or older in the world was estimated by UN to be 629 million. That number is projected to **triple** to 2000 million by 2050, when the population of older persons will be larger than that of children (0-14 years) for the first time in human history.

Old age is usually accompanied by physical and/or mental impairment (e.g. Alzheimer, Parkinson, etc.), observable in limitations and behaviours particular to each person. Assistance must therefore take account of individuality in terms of ameliorating the impairment and enhancing capability whilst ensuring safety, comfort, autonomy and due privacy. So, **the issue is very important to individual elderly people** but also to **family members and social agencies** that have a responsibility for arranging care for them, especially in a context where, in many parts of the world, including Europe, family structures are becoming much looser because, for instance, of higher mobility in the workforce. Often there is a stark choice between an elderly person moving to a new location with,

<sup>5</sup> It is worth noticing that the previous comments are also applicable to the “tools” and systems used during the construction process itself.

or close to, their family or being placed in institutional care. The costs of care are high both in the commitment of family effort or in hard € for institutional care paid for by agencies, relatives and the elderly themselves. The question is: **“Is there a viable, ethical ‘care at home’ middle way?”**. Note that the question includes role of national instances in charge of privacy of data and life, to be key in future scenarios so as to avoid negative reactions of targeted people (and public in general) towards deployment of such innovations in the future.

This scenario leads to some real **innovative role that ICT** will have in tackling the demographic and personal needs challenges for quality care viably provided. Objectives and targets are abundant and diverse, but one key problem domain largely deals with healthcare, as exhibited in the figure below. It may allow dealing with “preventative care” (portrayed in red in the figure) that takes account of medical, physical and mental states to safeguard an individual and intervene/warn before “crisis intervention” is required, as well as to deal with “reactive care” and crisis management.

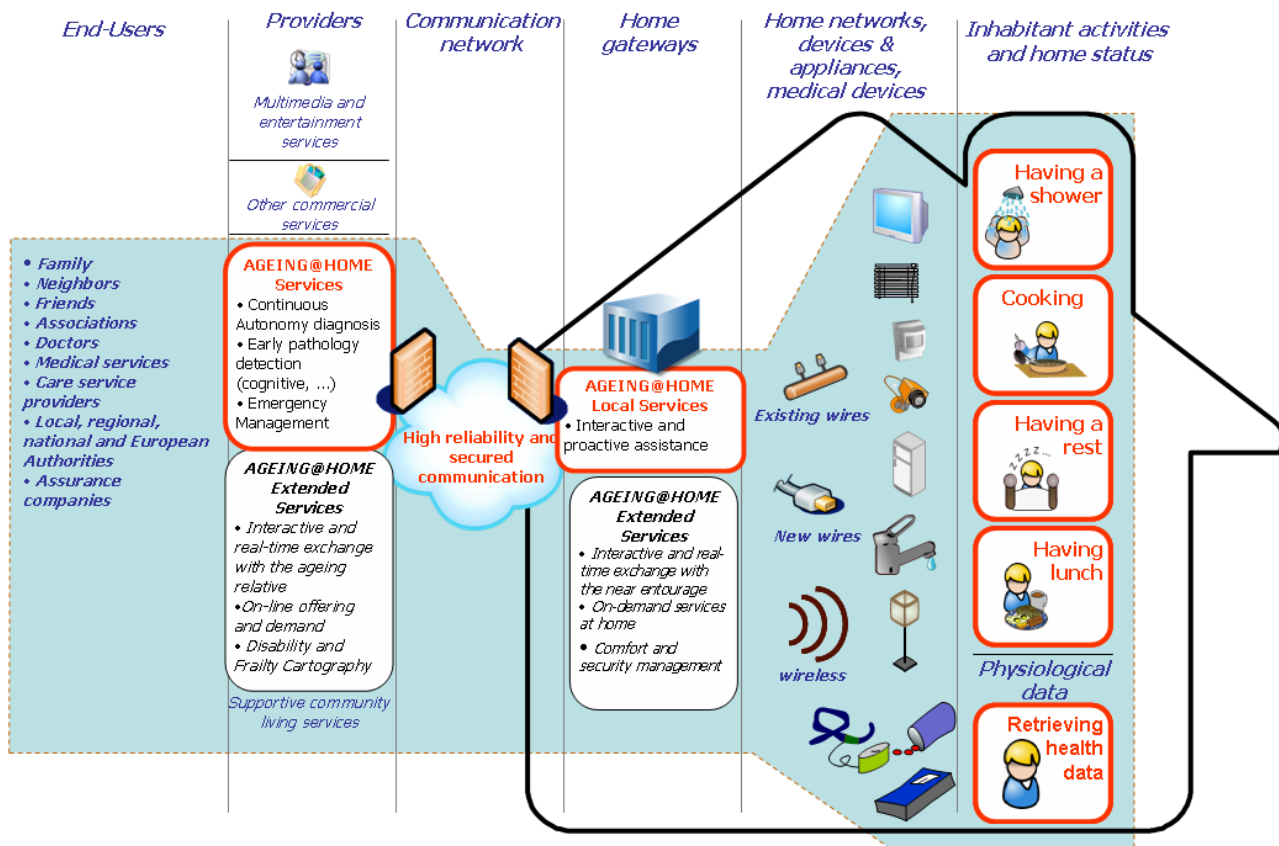


Figure 12: Innovative Ambient Services Targeting the Elderly in the Smart House of the Future

## Business Scenario: Positive-Energy Buildings

In front of the global warming and the risks of shortage of fossil energies, the European Construction area is directly concerned. Indeed, the housing is responsible for +40% of the power consumption, and +25% in France, for example, of the gas emissions for purpose of greenhouse effect. With a regular increase in the requirements in energy, stimulated by an always increased demand of comfort within the individual residences even more roomy, the building industry must implement corrective actions, as regards consumption, without degrading the levels of comfort, quality and safety desired by the end users.



Precursors on the matter, e.g. countries like Germany, Switzerland and even the United States<sup>6</sup>, developed new models of sparing homes in energy, even self sufficient and producers of energy towards outside. These models, called Passivhaus®<sup>7</sup> in Germany, Minergie®<sup>8</sup> in Switzerland or Zero Energy Homes® in the United States, use renewable energies ( as wind, sun, geothermics, biomass...) for the needs for the house, and restore the energy not consumed on a network which becomes a wide energy co-operative store. These models allow, for example for Minergie, to use only 1/3 of the power usually consumed by a traditional house. They recommend to improve in priority the insulation of the building (windows with double/triple glazings, reinforced insulation of the walls, phase change material...) before optimizing the treatment (production, ventilation..) of the calories in the winter, or the air cooling in the summer thanks to active thermal solutions ( more efficient heat pumps, thermal solar collectors, Canadian wells... ). As soon as the house become sparing in thermal energy, it can become producer of electrical power using photovoltaic solar panels first of all for the needs for the house, before reselling on the network, the surplus of electrical production.

But the improvement can also progress while equipping the house with "intelligent" solutions (environment sensors, dedicated software...) issued from ICT. Indeed, in addition to the fact that the owner of Positive Energy Building will have to run more and more complicated active equipment, it will be able to activate advanced devices, that will reduce or remove automatically useless consumption of energy, in real time, programmed or by anticipation of the evolutions weather (automatic release of solar blinds, screening of glazings electrochromes...). Conversely, when the user will be outside, these automatisms will allow without manual intervention, to benefit from favourable conditions weather, by storing electric or thermal energy.



Of course, the user will have to operate the same switching/control interface usually used for other applications as for example safety units, of comfort (quality of air, acoustics, infotainment services,...) and be in relation with remote automatic or manual hotline for maintenance assistance.

By comparison, a dashboard for energy home as the one supplied today into the hybrid car Prius®<sup>9</sup> becomes a reality thanks to the information technology. This equipment will permit soon to manage consumption and the storage of energy at home. Thanks to such equipment, it will be easy to decide, according to the instantaneous cost of energy, to sell or purchase electricity and to select different levels or strategy of consumption (economic, normal, forced, stand-by...) in real time or in anticipation.



<sup>6</sup> Even if the United States did not sign the agreements of Kyoto

<sup>7</sup> [www.passiv.de](http://www.passiv.de)

<sup>8</sup> [www.minergie.ch](http://www.minergie.ch)

<sup>9</sup> Manufactured by Toyota Company.

## Roadmap

### Objectives

The roadmap is to identify the various R&D axis required to transform the today living and working environments (houses, offices, buildings, etc.) in future smart environments and their innovative services, with a focus on all ICT artefacts that may support such an evolution. This includes:

- Developing integrated system architectures, innovative sensors and sensor networks, and models sustaining solutions for communication, operation and control, including ambient user interfaces, context awareness and embedded support for virtual working environments.
- Developing monitoring and assistance of the home, buildings and public spaces, with seamless interoperability and use of all devices taking account of cost efficiency, affordability, usability and safety;
- Developing new services and new forms of interactive digital content and services including entertainment, access to information and management of knowledge. Such services should allow, for instance, the control and optimisation of energy fluxes and production over a full life-cycle operation of the building, or provide continuous support to people living or working in the building (e.g. elderly / disabled people, see scenario 1).
- In parallel, consolidating international experiences from intelligent constructions and suggest best practice, improved regulations and standards covering new constructions and retrofitting, and develop dissemination, experimentations, evaluations, training and certification around products and services for the smart houses.

Additional considerations are related to, on one hand, the acceptance of such ambient ubiquitous interactive services (which seems highly connected to the levels of both security and pervasiveness that such communicating objects and services may provide), on the other hand, the economic viability of services that could be imagined and further deployed.

### Main Research Areas

The R&D targeting the intelligent constructions and smart houses is to be developed around three fundamental pillars:

- The **“intelligent” objects**: these objects must have embedded electronic chips, as well as the appropriate resources to achieve local computing and interact with the outside, therefore being able to manage appropriate protocol(s) so as to acquire and supply information.
- The **communications**: these must allow sensors, actuators, indeed all intelligent objects to communicate among them and with services over the network. They have to be based on protocols that are standardised and open.
- The **multimodal interactive interfaces**: the ultimate objective of those interfaces is to make the in-house network as simple to use as possible, thanks to a right combination of intelligent and interoperable services, new techniques of man-machine interactions (wearable computing, robots, ...), and learning technologies for all communicating objects. These interfaces should also be means to share ambient information spaces or ambient working environments thanks to personal advanced communication devices.

Time-wise, the following need to be developed:

**Short term:** the R&D is devoted to achieving full integrated automation and control, leading to the **e-HOME** – the “electronic HOME”. This is mainly about:

- All objects / components in the built environment integrating elements for a given degree of intelligence: RFID tags, chipsets, embedded micro-systems, etc., including the opportunity for humans to wear such devices or chips with embedded intelligence.

- Application of sensor technologies for distributed monitoring, control, end-user support and services, thanks to all “intelligent” communicating objects being able to mutually identify in the network, connect and interact with each other according to various communication models and channels.

**Medium term:** the R&D is devoted to the generalisation of network-based services accessible from home, leading to the **i-HOME** – the “interactive HOME”. This is about considering the built environment being naturally considered as a node (or set of nodes) of the Internet backbone, therefore providing and requesting services over the network:

- Smart products and systems with embedded devices, and embedded learning support to users, operators and maintenance staff.
- Software tools for tracking, logistics, diagnostics, monitoring and control.
- Modular integrated automation, monitoring and control of all subsystems with holistic optimisation and support to service provision.

**Long term:** the R&D eventually is targeting a full understanding and adaptability of the home as regards people living in it, leading to the **u-HOME** – the “ubiquitous HOME”. This includes:

- User and context aware, self-optimising intelligent built environments, with potential for dynamic re-configuration, and providing access to interactive spaces and personalised services.

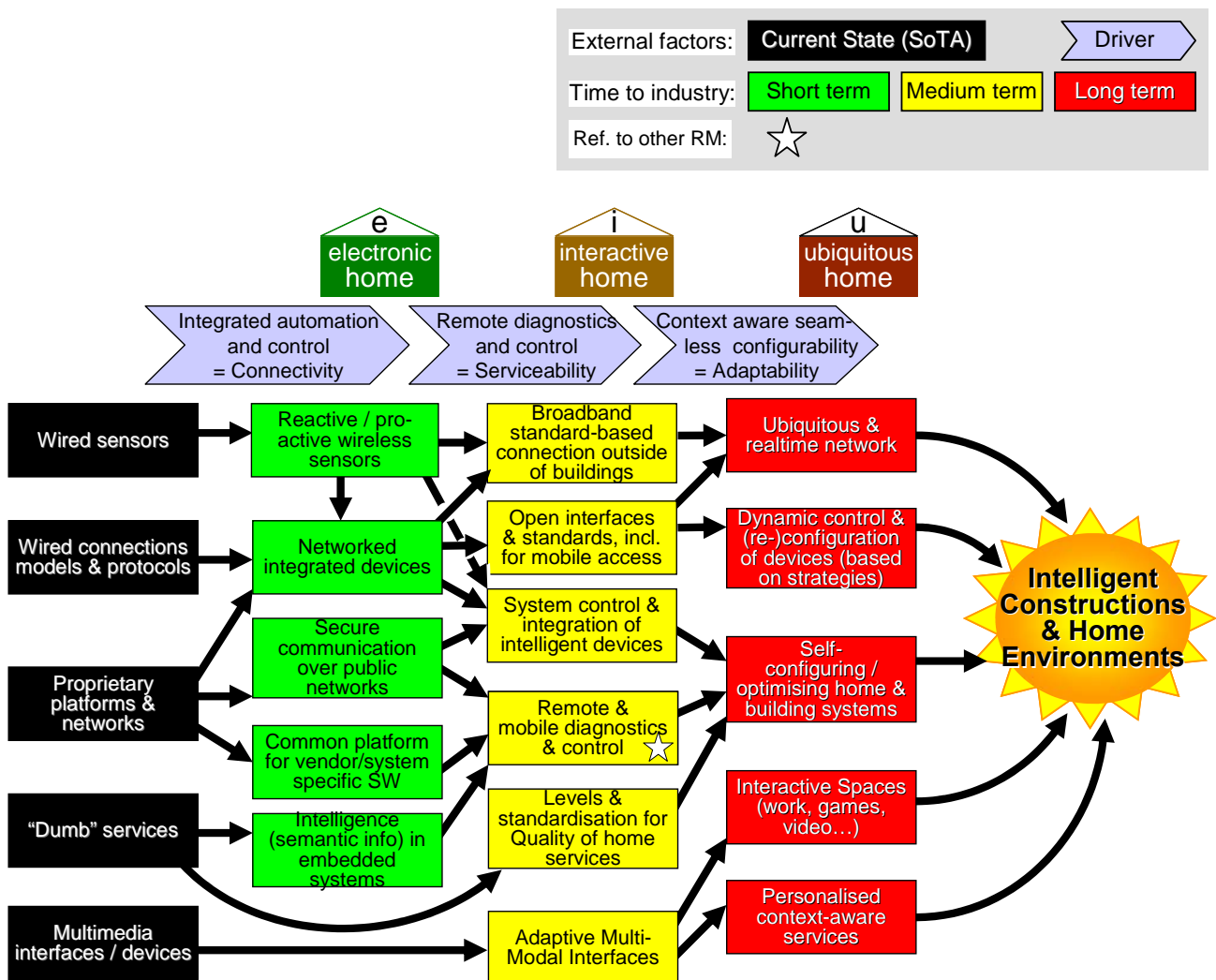


Figure 3: Roadmap for Intelligent Constructions

## Current State of the Art

- Wired sensors: lots of various remote controlled devices, with the use of such devices (HVAC, lighting, audio-video equipments...) being currently investigated in the built environment through preliminary deployment and experimentations.
- Wired connection models & protocols: still under development and even more looking for harmonisation and standardisation (NFC - Near Field Communication, Bluetooth, Wi-Fi, RFID, ZigBee, etc.), they aim at establishing and managing communication between objects.
- Proprietary platforms & networks: current platforms implementing connected objects are mainly experimental platforms, with no standardisation of management of and communication between any kind of “intelligent” objects.
- “Dumb” services: all services provided by the industry so far are specialised / dedicated services that ensure one given function, without providing interoperability, and no capacity to “talk” with other services or to take into account the full environment.
- Multimedia interfaces / devices: still few intelligent objects that are not intrusive and offer appropriate interfaces to allow the final user to seamlessly integrate the ubiquitous network.

## Time to Industry: Short Term

- Reactive / proactive wireless sensors: sensors that are able to integrate a set of contextual data and compute them before providing information corresponding to any request. As a potential chain in an overall process, they should also integrate behaviour patterns to proactively fill in a given mission.
- Networked integrated devices: the achievement of such network integrated devices (such as home appliances and site equipments) should allow the development of new applications seamlessly and dynamically integrating through the network any autonomous device, based on its universal ID, its dedicated API, and its capacity of active / reactive behaviour.
- Secure communication over public networks: this should allow exchanging any type of information, including private information whenever required, between smart components and/or houses, and e-services over any type of networks, including the Internet. This means both in terms of reliability of the transport (i.e. no loss of alteration of the data), than in terms of privacy and security of conveyed information.
- Common platform for vendor/system specific SW: must allow the integration of any devices / components (sensors, actuators, transmitters, chips in building components and furniture, ...) so that these objects can collect data, compute them, send them, thanks to standardised operating systems and platforms. This is also related to specifying format of objects for distributing the middleware. Such systems/platforms must form the ground for “spatial information systems” able to link objects in a physical space.
- Intelligence in embedded systems: Embedded systems should make their (Construction) containers “smart” by being able to deal with semantic information (query and get) and to manage it (locally analyse, compute, and provide output - in case according to pre-defined or dynamic strategies) so as to integrate a network of smart sub-systems that form the smart house / building.

## Time to Industry: Medium Term

- Broadband standard-based connection outside of buildings: need for environments subject to automation to be integrated in networks and systems that provide proved and reliable communicating channels, including for large in and out data streams.
- Open interfaces & standards, including for mobile access: coherency between information managed by the “intelligent” ambient objects... They are a key angular stone to the Software interoperability which still remains an issue in a context where all the intelligent objects have to organise themselves and communicate spontaneously over the network.

- System Control & integration of intelligent devices: specify and develop enhanced products characterised not only by improved features (e.g. optimising the equation quality/duration/cost) and capabilities (e.g. smart buildings), but also shipping with e.g. fully digitalised, unique and personalised, universal electronic cards or digital mock-ups, that could manage the information structuring and integration for the product, allowing traceability of all parts of the final end product (so as to provide all guarantees of quality and safety to the client), and long-term memory of end products for maintenance, enhancement, refurbishment, and even the demolition process (in terms of potential reuse of parts of the building). Such products / devices will communicate by embedding appropriate tags (RFID, etc...), and will allow to improve global monitoring of complex systems in the built environment.
- Remote & mobile diagnostic & control: achieving diagnostic / control and indeed leading to decision-making systems will require semantic based content integration (including data fusion), i.e. specify and develop algorithms and solutions that will achieve syndication of information from a semantic point of view leading to a seamless integration of data from disparate and multiple data sources. This will especially rely on BIM<sup>10</sup> in the context of the built information.
- Levels & standardisation for Quality of home services: identify and classify different levels (defined by some sets of indicators and parameters) for Quality of services in smart homes and buildings. Such levels should provide Quality repositories for service developers and providers to target a given level (as a level of service ensured to the end user), as well as to achieve tests and evaluation and deliver certification for new home services.
- Adaptive Multi-Modal Interfaces: this is about the achievement of intelligent user-friendly interfaces, i.e. identify, specify and develop systems allowing context-based multiple modes of interaction, augmenting human to computer and human to human interaction (including potential interaction with robots), adapting to the devices, user preferences and contextual conditions, and available / accessible to all. One step is the evaluation, adaptation to the Construction processes, and integration of such systems (currently developed in research centres and laboratories), including speech recognition interfaces, rollable & foldable displays, head-mounted display devices, and holographic applications.

### Time to Industry: Long Term

- Ubiquitous and realtime network : develop solutions and systems exploiting the 4th Generation Broadband Mobile Network that will provide the best interactive and intuitive collaboration / communication services than any alternative networks, including high-level security, better QoS, mobile and audio / video conferencing enabled, improved wireless data protocols, etc. → **achievement of Ubiquitous & secure communication**
- Dynamic control & (re-)configuration of devices (based on strategies): develop algorithms and architectures for any configuration of smart devices (i.e. any set of such devices being interconnected) to be able to dynamically evolve according to the environment or change in a choice of a global strategy. This includes as well individual “roaming” profiling, allowing configurations to follow users, related to a wide variety of applications.
- Self-configuring home & building systems: develop architectures where Component-based in-house systems learn from their own use and user behaviour, and are able to adapt to new situations, locating and incorporating new functionality as required. Situations are automatically tracked and significant events flagged up. Intelligent assistant maintains a view of the users responsibilities, finds needed resources as required and priorities events and tasks, making relevant services available as needed. This included use of pattern recognition to identify and prioritise key issues to be addressed, and to identify relevant information.

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<sup>10</sup> Building Information Models (a typical example of such a BIM is the IFC model).



- Interactive spaces: develop architectures and systems that offer smart audio, video, leisure and working environments that must be adaptive and “immersive”. This includes agent-based user interfaces adaptation to suit user preferences and profile inferred from usage habits, and Advanced Identity Management (based on a follow-up of the progress in current research in this field, e.g. biometrics), to identify and assess the potential of integration of these technologies in services dedicated to Construction.
- Personalised context-aware services: identify, specify and develop smart systems that easily integrate or connect to the house or building, and that are Context aware systems providing services to support personalisation and context data processing, and interpretation of information on the user and his environment in order to provide seamless information access and gathering for each stakeholder, as well as value-added information dependent on the context.

## Impacts

These solutions shall increase comfort, security and safety at working and living place and reduce energy consumption, and needs for travelling and transports.

Such a roadmap supports the policy priorities for the Information Society as highlighted in the i2010 initiative. As regards all the services for the inhabitants, it is worth noticing that Viviane Reding<sup>11</sup>, in a keynote speech at the i2010 Conference in London in September 2005 set out pillars of activity instrumental in taking forward policy and research programmes on e-Health, e-Government and e-Learning. She said *“these continue to be pivotal to the agenda for ICT-enabled public services, but very often all the efforts we have been making in these areas have not received the attention they merit. That is why in i2010, I have proposed three ICT flagship initiatives to give critical mass to our work in three important and visible areas where ICT has a positive impact on citizens: the first flagship aims to make our ageing society a better place to grow older with independence and dignity. The flagship will build on our research initiatives on assistive living, eHealth and eAccessibility and be used as a basis for prioritising both research and policy in the coming years.”*

Considering the case of PEB, there are of course evident social impact: reducing (and in a more long-term inverting) buildings consuming of energy, reducing buildings pollution (i.e. reduction of CO<sub>2</sub> and other gas emission), provide alternatives to energy production as regards current classical production (petrol, fossil, nuclear...), with overall reduction of nuclear-based production, overall reduction of petrol/fossil production, etc.. But impact is at level of the Building industry too, with control and optimisation of energy fluxes and production over a full life-cycle operation of the building. The technologies developed at level of each component should also allow 0-default “knowledge-embedded” building components to be immediately assembled on Construction sites – with assembly done easily, even with low-level human power.

Indeed, emergence of new concepts like energy self sufficient buildings or Energy positive buildings connected to energy distribution networks might become a common practice in a sustainable economy. A local market of energy exchanges between buildings in micro urban area should become a common situation. Developing technologies and practices will not only improve sustainability and competitiveness of Europe, but also offer possibilities of transferring technologies to developing countries, contributing to solve the great global problem on sustainable energy uses. Experimental and demonstration buildings in the last two decades proved the technical feasibility of such concepts. Some European countries or regions of these countries entered the process of progressively generalizing such practices.

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<sup>11</sup> EC Commissioner for Information Society and Media.

## Thematic Mapping and Further Information

FP7 Information & Communication Technologies	<ul style="list-style-type: none"> <li>• Home environments.</li> <li>• Embedded systems, computing &amp; control: <ul style="list-style-type: none"> <li>– Open composable architectures &amp; scale-free platforms.</li> </ul> </li> <li>• ICT meeting societal challenges: <ul style="list-style-type: none"> <li>– Health (personal non-obtrusive systems, autonomous systems).</li> </ul> </li> </ul>
FP7 Health	<ul style="list-style-type: none"> <li>• Innovative therapeutic approaches &amp; interventions.</li> <li>• Translating clinical research into clinical practice.</li> </ul>
FP7 Energy	<ul style="list-style-type: none"> <li>• Smart energy networks.</li> <li>• Energy efficiency &amp; savings.</li> </ul>
FP7 Environment	<ul style="list-style-type: none"> <li>• Technologies for managing resources or treating pollution (e.g. while operating buildings) more efficiently.</li> </ul>
ROADCON 2003	<ul style="list-style-type: none"> <li>• Adaptive and self-configuring systems.</li> <li>• Ambient access.</li> <li>• Smart buildings and embedded systems.</li> </ul>
FIATECH 2007	Element 5: Intelligent Self-maintaining and Repairing Operational Facility



# Roadmap: Interoperability

**Main Business Drivers:** Data/file exchange => Data sharing => Flexible interoperability

**Key Research Topics:** Model servers; Distributed adaptive components; Ontologies & open ICT standards for semantic communication; ICT infrastructures.

## Background

The current state of interoperability in the construction sector today can be summarised as follows:

- Despite promising developments of object modelling and data exchange standards such as IFC, increasing use of semantic "nD" applications continues to face huge interoperability challenges.
- Available solutions address static data but not dynamic product behaviour.
- Interoperability problems limit the potential benefits of new and emerging ICT, cause extensive information management overload, limit possibilities for business collaboration between geographically remote partners, and limit the introduction of new and innovative products & services to the market.

## Vision

### Target State

Interoperability encompasses several aspects, should they be mainly technical (e.g. related to networks or software applications) or more linked to organisational and process issues (thus in relationships with the "Collaboration support" roadmap). For instance, the European Interoperability Framework (EIF) for eGovernment services for EU citizens (as proposed for development in the eEurope 2005 Action plan) describes three aspects of interoperability: technical, semantical, and organisational. Quite synthetically:

- Technical interoperability is about linking up computer systems through network and data transport protocols and standards;
- Semantic interoperability is about same meaning / understanding of data semantics between systems to process received information in the right way;
- Organisational interoperability is about modelling and harmonising business processes and their organisation, while ensuring their availability to end users.

*The vision proposed in this roadmap is that in the future, relying on interoperable and standardised data transfer protocol, semantically rich information will be shared by the Construction Sector throughout the whole life-cycle of buildings and the built environment by means of integrated information systems and services encompassing all processes and their interactions. To achieve such a desired state, it is required that:*

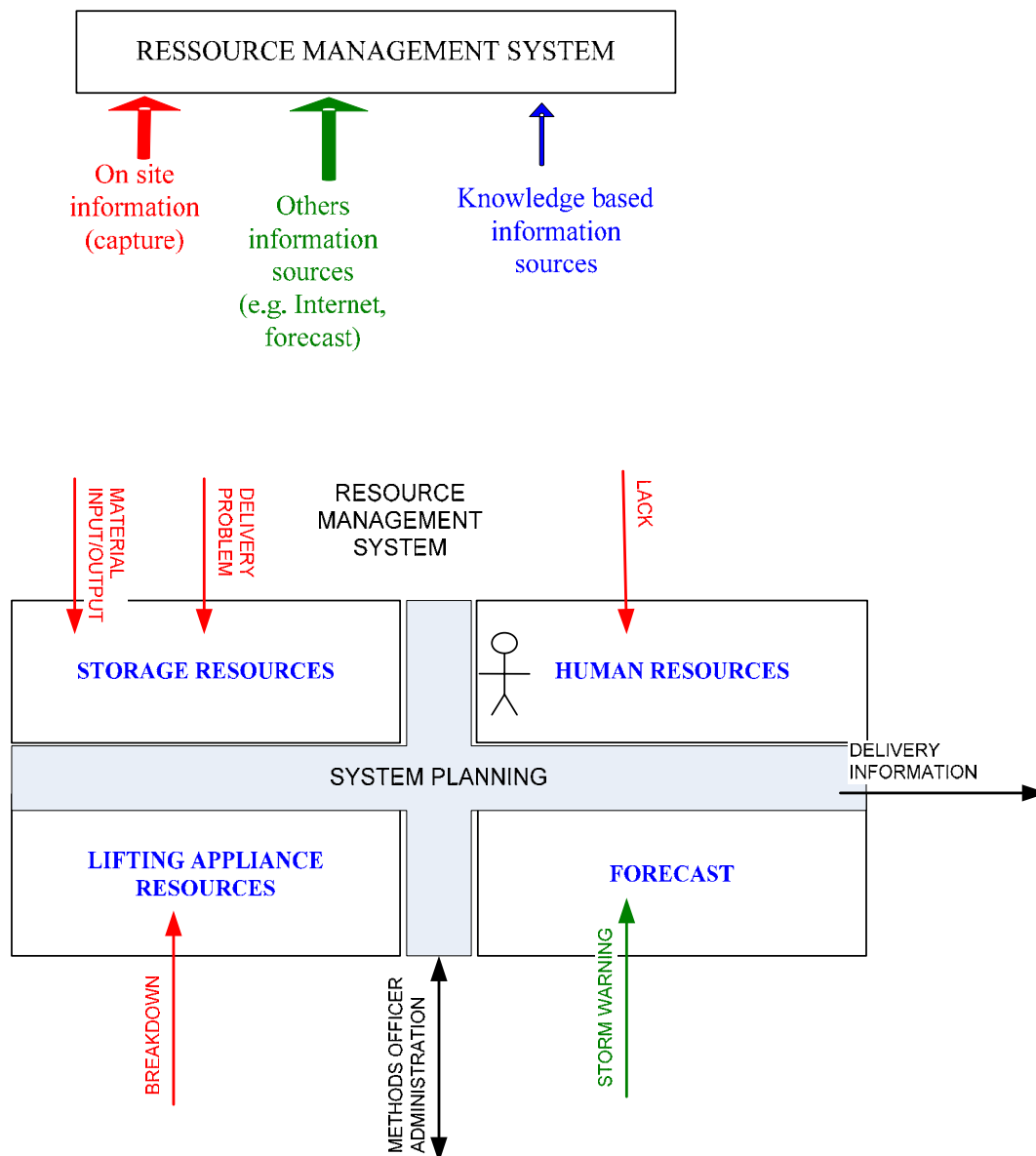
- Any of two or more IT components or systems have the ability to communicate and jointly utilise the information, especially thanks to the definition of its semantics;
- Communication of information semantics is effective thanks to international or industry standards (rather than proprietary standards), and preferably thanks to open standards, which are to be product, services and systems-independent, background technology agnostic, and having their specification freely available to all interested parties.

Fields of applications of R&D developments in Interoperability have quite a large spectrum: we shortly introduce to some of them in the scenarios below, without any pretension in terms of exhaustivity.

## **Business Scenario: Resource Management System in the Construction/Manufacturing phase**

The construction site of the new Hospital of MYTOWN has started for 5 months. It should finish in one year. After earthwork and foundation phases, the first floor of the main building is above ground and the floor slab (flagstone) of the second floor is now under construction.

BARBENDER company was informed (the week before) by email/SMS that its “window” of reinforcements delivery was to take place at 2PM tomorrow. This information is made possible thanks to the Resource Management System which takes into account the needs for materials of the building site (management of the stock of materials), the availabilities of the lifting equipments, the availability of storage areas and human resources availability to achieve the unloading and the reception of the delivery.



**Figure 13: Resource Management System**

Two days before the delivery, the company delivery manager receives a message indicating to him to postpone (defer) its delivery to the following day under the reason that the crane requires an intervention of maintenance following a breakdown.

A new generation of Resource Management Systems should allow to manage events (in real time) which occur on the building site: breakdown of a machine, forecast weather, absence of manpower etc...

All this information “is collected” in real time by “ad hoc” communicating equipment adapted to the constraints of robustness, minimal size, reliability and ergonomics of the interface.

Methods officer was of course immediately informed of the breakdown, he is then able to reorganize the continuation of the work to avoid the layoff and the delay in planning. He is in addition informed of the inventory position of materials on the site, thanks to the identification (tagging) procedure (bar code, RFID) of all entry or export of the merchandise toward a storage area of the construction site or a straightforward use on the construction site.

The Resource Management System takes into account the delivery management: date, place, hour, expected (awaited) data-processing marking (tagging) (on the delivery order, or the RFID chip), route to follow taking into account the volume or the tonnage of the merchandise, site storage location and also the events relating to non conformity of the delivery or bad delivery condition.

### **Business Scenario: Smart Building in the Service Phase**

This scenario illustrates a typical use case of new equipment to be integrated in an operational building. This equipment is intended to contribute to the overall strategy for building operation: saving energy, improving brightness control, increasing thermal comfort etc.

Mr. Smith has bought a motorised rolling shutter. The shutter is fully compliant with CSTBAT-Communic® standard recommendations which refer to semantic networked computing. Typically the recommendations are based on interoperability standards such as OSGi Alliance, IPV6, UPNP, W3C-DI and FIPA. In addition the equipment is compliant with HQE standard (High Environmental Quality) and generally contributes to the sustainable International policy.

Mr. Smith has fixed the shutter over a window on the outside south wall of his house and connected it to the power supply. The shutter is immediately automatically identified and authenticated on the network since the electricity network supports IPV6 and is compliant with HomePlug Alliance recommendations. Hence immediately the communicating store sends signals to other communicating building components providing information to them such as: its name, function and features. At this point no human parameterisation is needed: this is plug-and-play building equipment.

Then the store searches on the network to find some central controlling “assistant or manager” to specify its behaviour according to the selected global strategy of the controlled building (energy, comfort etc). However the shutter cannot find any such information support and so adopts a basic default strategy based on the weather forecast. On its own initiative the equipment look for a local forecast station or a specific sensor such as a wind gauge or a rain gauge.

But it cannot find such an information service on the building network, and so looks for a local Internet forecast service. This service aids it in its simple strategy:

- roll down the shutter when local forecast information indicates: "sun shines";
- roll up the store when local forecast information indicates: "rain or high wind" etc..

The communicating shutter is now a component of the building network – a power and knowledge network. However, if a manager component is introduced to take control of the building network, the shutter becomes a servant of the strategy set by the manager.

Mr. Smith is no longer involved in configuring the shutter, especially in the integration of the new equipment in his house. But in case communicating equipment requires a decision from Mr. Smith,

a display resource (like a terminal, TV, PDA) can be used. Moreover equipment choice is widened, since interoperability of new equipment is guaranteed whatever the manufacturer or trademark.

## Roadmap

### Objectives

The roadmap is to identify the various R&D axis required to transform the current eBusiness processes environment(s) into fully integrated / interoperable innovative semantical eServices supporting structured and harmonised processes in Construction, with a focus on all ICT technologies and tools that may support such an evolution. This includes:

- Providing seamless semantic (forward and backward) communication (object exchange and sharing), to support both interfacing and synchronisation between actors;
- Integrating (open and standardised) nD modelling technologies, Semantic Knowledge Technologies (SKT), Grid-based Computing, and Global Optimisation methods, along with intuitive visual and interactive user interfaces;
- Developing and refining architectures for construction product/service life-cycles and their associated supply chains, that are adapted to the Construction sector (especially SMEs), with easy methods and techniques for specialisation;
- Offering flexible access to IT-based business services, semantic information resources and Content repositories / libraries of re-usable solutions, with standardized global identification of construction objects;
- Offering capability to provide services for installing, maintaining and monitoring these advanced systems (strengthening the role of system integrators in construction).

### Main Research Areas

The R&D targeting the Interoperability issues is to be developed covers:

#### **Short term:**

- Development and use of enhanced standards scope consolidation.
- Take-up of solutions supporting dynamic linking of documents to different model elements

#### **Medium term:**

- Development of model-based applications and agents
- Development of model APIs, model servers, and object-based ontologies to support semantic web services

#### **Long term:**

- Web-based logic and reasoning supporting self organising context aware systems
- Open object oriented ontologies to support semantic based content integration
- Object servers and distributed adaptive components

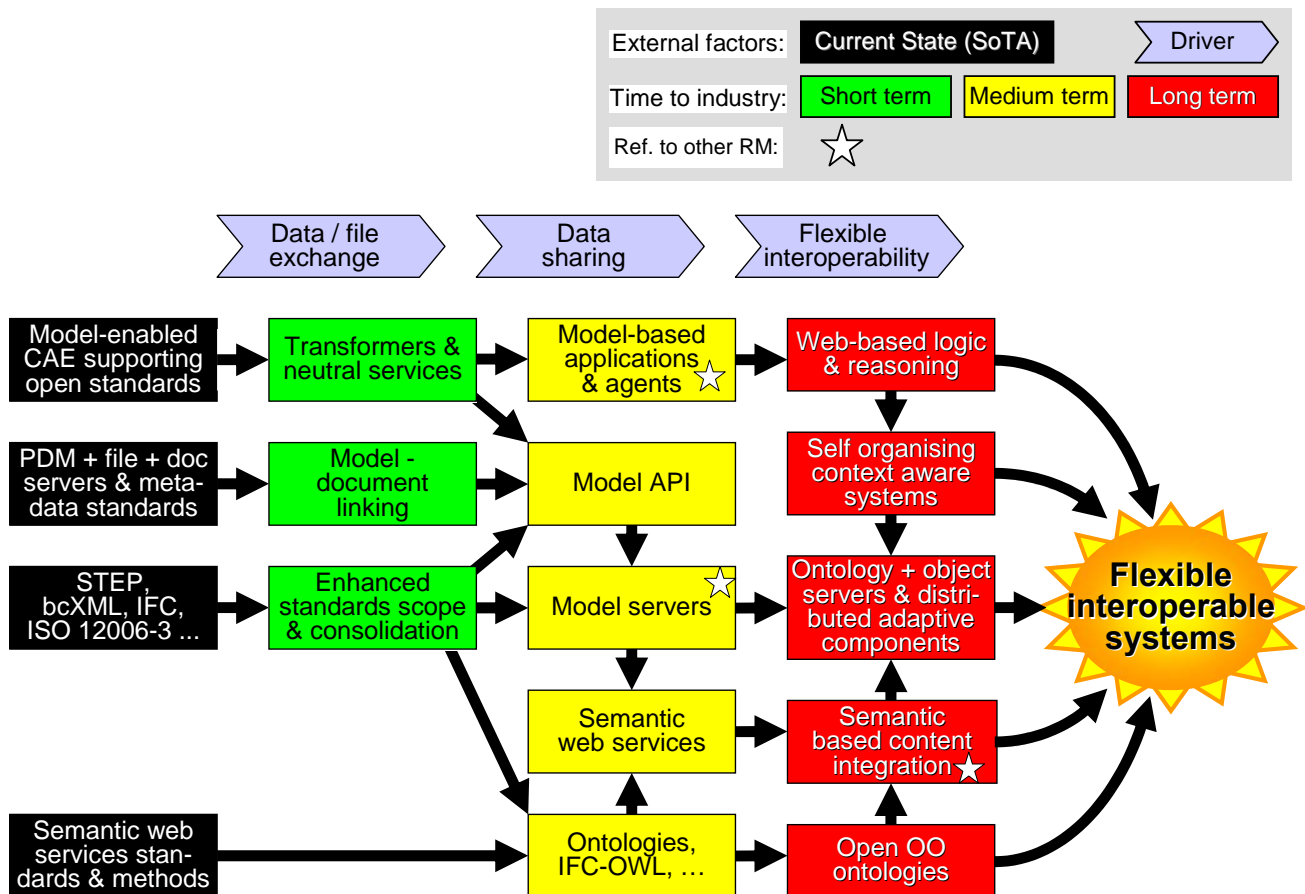


Figure 14: Roadmap for Interoperability

### Current State of the Art

- Model-enabled CAE supporting open standards: Computer-aided engineering (often referred to as CAE) support engineers in tasks such as analysis, simulation, design, manufacture, planning, diagnosis and repair. Software tools that have been developed for providing support to CAE encompass simulation, validation and optimization of products and manufacturing tools. Already today, and even more in the future, CAE systems have to support design teams in decision making, based on data and information coming from multiple sources and multi-disciplinary simulation, relying on formal modelling and already existing open standards.
- PDM, file, doc servers & meta-data standards: technologies allowing enterprises to establish business process relations and cooperate with other enterprises, and to increase their co-operations during the entire product life cycle, are the ones mainly based on product data modelling (*see also next bullet*) leading to potential product data management through file exchange between applications, or access to data servers through APIs relying on models / meta-models. Additional meta-data may already facilitate the search for specific types of data.
- STEP, bcXML, IFC, ISO 12006-3: In the past 15 years, standards and norms have already been developed, with tangible progress (even if still under development), like the STEP norm (ISO 10303, introducing a set of norms for the modelling, exchange and management of product data), or the IFC standard, a comprehensive model for the formal and structured description of buildings through objects and Property sets, the latter dealing with extensions to the Core model. Another example is the ISO 12006-3 standard, that defines a schema for a taxonomy model, which provides the ability to define concepts by means of properties, to group concepts, and to define relationships between concepts, with objects, collections and relationships being the basic entities of the model, and the set of properties associated with an object providing the formal definition of the object as well as its typical behaviour.

- Semantic web services standards & methods: Service Oriented Architectures (SOA) form a computing paradigm that has emerged from Object and Component based approaches, so as to organise and access distributed resources thanks to on-the-fly service creation and use, based on loosely coupled, reusable software components. Well developed forms of SOA are the Web Services relying on XML standards to provide a coherent platform for building loosely coupled distributed applications. Semantic Web Services aim to combine concepts of the Semantic Web with Web Services technologies. The Semantic Web intends to create a universal medium for information exchange by putting documents with computer-interpretable meaning (semantics) on the Web. The key standards and tools of the Semantic Web are XML & XML Schema, Resource Description Framework (RDF), RDF Schema, and Web Ontology Language (OWL).

### Time to Industry: Short term

- Transformers and neutral services: Transformers (Mappers, Translators, Convertors) for "beyond-CAD" support and neutral services/utilities (viewers/browsers/editors like IFC browsers). Where standards do not exist, they act as "interfaces" that support interoperability across standards and proprietary applications.
- Model-document linking: Natural links between different model objects and relevant documents/drawings/CAD files, etc. These could as an example be based on "association and/or derivation".
- Enhanced standards scope & consolidation: The scope of standards should not be restricted to a particular project phase or actor. Rather, standards should be enhanced and broad to cover the complete product/project lifecycle, supply chain, all process and all actors. Where possible, standards could be enhanced through consolidation of different "parts" of different standards to form a "whole" standard.

### Time to Industry: Medium term

- Model-based applications and agents: Model-based applications & Smart agents that can work with open grammar/syntax, ontologies and corresponding content. This would lead to new business opportunities enabled by model based data e.g. analysis, estimation, visualisation, multi-disciplinary simulation, etc.. Thanks to computer-interpretable information highly specialised services using sophisticated software become feasible.
- Model API: Open model-level API allowing for flexible communication across applications manipulating different product and/or process models. This could exist in the form of a metamodel enabling flexible extensions to standard models based on specific needs which are not covered by the standard.
- Model servers: Object Oriented (distributed) model servers that may reside in different organisations and yet have the capacity and capability to communicate with each other. Grid technology may be one solution to support distributed model servers in terms of service discovery, interoperability and mainly security. It should be noted that while a specific model server (e.g. within an organisation) may contain a relevant part (or view) to the overall product/process model, these parts should through the distributed model servers be mergeable to form the complete model (containing all parts, and of course views).
- Semantic web services: Semantic Web Services (SWS) methods and tools supporting fully integrated semantic web services technologies to support and enable increased intelligence of applications and interfaces for communication with other applications.
- Ontologies, IFC-OWL: (Actual) Semantic Web-based Ontologies (global, detailed, generic, specific) and Web Services (WS) services supporting a digital framework for developing engineering models, and offering a basis for high-level functionality on top of existing model servers.



## **Time to Industry: Long term**

- Web-based logic and reasoning: Open Web-based Logic & Reasoning (on top of semantic web services) supporting distributed service integration and interoperability, as well as dynamic composition of services
- Self organising context aware systems: Systems that are self-configurable upon demand for a given purpose or project. These systems are expected to support the ICT operations of a virtual enterprise. It is the scope, purpose, and needs of modus operandi such as that of a virtual enterprise that determine and lead to the self-organisation (configuration) and optimisation of such systems.
- Ontology + object servers and distributed adaptive components: Ontology/Object servers supporting distributed and context aware adaptive ICT components that are responsive to given user/organisational requirements for a given purpose (task) or project.
- Semantic based content integration: Use of semantic technologies (semantic web + ontologies) to inter-relate different forms of content and media to form a whole.
- Open Object Oriented Ontologies: Open Object Oriented Ontologies (not just data-driven) to support definition, configuration, and visualisation of different instances of product/process components. The key points here are openness and object orientation. These ontologies are not necessarily domain specific; rather they offer the capability for convergence of different domain ontologies to serve a given instance/purpose and rely on semantic technologies for this convergence. The convergence itself may be seen as an operational meta-ontology.

## **Business Impacts**

ICT-based interoperable service platform(s) and system(s) that will allow a full-fledged *Business Service oriented* approach, allowing to move from “design for the customer” to “design by the customer”, and making possible the quick delivery to all Construction stakeholders of new products and service concepts for the entire life span of the buildings / infrastructures and for its various functions, and the creation of new service markets.



## Thematic Mapping and Further Information

FP7 Information & Communication Technologies	<ul style="list-style-type: none"> <li>• Software, GRID: <ul style="list-style-type: none"> <li>– Services-based infrastructures.</li> <li>– Open platform.</li> </ul> </li> <li>• ICT supporting businesses and industry <ul style="list-style-type: none"> <li>– collaborative work environments</li> </ul> </li> </ul>
FP7 Nanosciences, Nanotechnologies, Materials & new production technologies	<ul style="list-style-type: none"> <li>• Networked production <ul style="list-style-type: none"> <li>– Supply Chain Integration and Real-Time Decision Making in Non-hierarchical Manufacturing Networks.</li> <li>– Interoperability of technical business solutions in production networks.</li> </ul> </li> <li>• Rapid transfer and integration of new technologies into the design and operation of manufacturing processes  <ul style="list-style-type: none"> <li>– Knowledge Based Manufacturing – Integration of Heterogeneous Data and Enhancement of Human Interactions in Manufacturing Environment.</li> </ul> </li> <li>• Integration of knowledge for sectoral and cross-sectoral applications <ul style="list-style-type: none"> <li>– Industrialised interoperable production systems for off-site and on-site production.</li> </ul> </li> </ul>
ROADCON 2003	<ul style="list-style-type: none"> <li>• Flexible interoperability.</li> <li>• Model-based ICT.</li> </ul>
ELSEWISE 1997	<ul style="list-style-type: none"> <li>• Data exchange.</li> <li>• Distributed object oriented databases.</li> <li>• Open interfaces.</li> <li>• Shared project database.</li> <li>• Standards.</li> </ul>
FIATECH 2007	Element 9: Lifecycle Data Management & Information Integration

## Roadmap: Collaboration Support

<b>Main Business Drivers:</b>	rapid and easy connectivity => robust team interaction => seamless inter-enterprise integration
<b>Key Research Topics:</b>	ICT tools for information sharing, project steering, negotiations, decision support, risk mitigation, etc.

### Background

Electronic business activity is less developed in the construction industry than in manufacturing sectors. A multitude of standards, technical specifications, labels, and certification marks is dominating. Many companies prefer to be *re-active* rather than *pro-active* in their use of ICT. The construction industry has yet to show the same level of ICT driven improvement of productivity as in other industries. This can partly be explained by the nature of the work and the type of production involved in construction processes. It is also related to slow uptake of ICT in a sector which is dominated by SMEs. Large enterprises in the industry and new sector entrants have adopted ICT based production methods. However, there is still great potential for further ICT uptake for instance in the field of *collaborative working environments*. Most companies in the sector tend to organise work around individual construction projects which has led to a fragmentation in ICT use and e-business activity, characterised by a lack of commonly accepted standards, technical specifications and labels. (Source: e-Business Sector Studies – Construction (<http://www.ebusiness-watch.org/resources/construction/construction.htm>)).

The current situation can be summarized as follows:

- Current collaborative environments ("project web sites") provide basic file/document management and basic collaboration tools.
- Use of advanced collaboration tools is constrained by short project durations and concurrent participation of stakeholders in many projects at the same time. This leads to difficulties regarding costs and learning to use multiple systems.
- There is no legal framework to support the introduction of ICT tools (and especially such as collaborative tools) in project management.
- Despite promising developments of object modelling and data exchange standards such as IFC, increasing use of semantic "nD" applications continues to face huge interoperability challenges.
- Available solutions address static data but not dynamic product behaviour.
- Interoperability problems limit the potential benefits of new and emerging ICT, cause extensive information management overload, limit possibilities for business collaboration between geographically remote partners, and limit the introduction of new and innovative products & services to the market. Especially, *a fundamental and growing problem is the disparity of internal enterprise systems and external project environments*.
- In addition to CAD/CAE tools, product data in other industry sectors is managed by so called PDM systems which are rarely used in construction. Generic PDM addresses document and workflow management for large organisations and their suppliers. Consequently setting up a PDM system is time consuming and expensive, and not feasible in a project oriented sector like construction. Furthermore, construction is already moving from documents to modelling.

## Vision

### Target State

The vision of future collaboration support in the Construction industry is as follows:

- Internal enterprise systems are connected to external collaboration environments with project partners in a transparent way.
- International standards enable fast set-up of collaboration platforms for new project consortia.
- Collaboration environments support social cohesion and trust among geographically distributed, cross-organisational teams with multidisciplinary skills, multiple cultures and multiple languages.
- Collaborative environments support mobility in a seamless way, covering all the phases of the construction process including construction sites.
- Advanced collaboration tools are easy to use without system specific training.
- Virtual meeting spaces enable (a-) synchronous communication.

### Business Scenario: An “Intelligent” Virtual Project Space

Different companies are working on a large scale building project. The specific handicap thereby is the fact that they are dealing with an enormous amount of information that has to be controlled. Therefore, the in- and outgoing data has to be processed. In terms of internal and external communication the participants are sharing a web-based platform, which is able to structure and administrate all incoming and outgoing data. The virtual project space allows “strategic” data exchange between all participants. A system of access codes allows regulating access and manipulation of deposited data in a useful manner. In that case it is rather useful to predefine a hierarchy that regulates the rights to handle, bring in, change and exchange data. Furthermore, the assigned time of manipulating the data is well-defined.

The system itself works as a real-time based shared data-platform, which is collecting and preserving all relevant building-information. It is shared between all relevant members of the team. It provides and offers all necessary information during the process of planning, construction and ongoing during the whole lifecycle of the building. The cumulative information is interconnected to a three-dimensional model of the building. Diverse interfaces allow access to relevant information from any point in the world.

### Business Scenario: “e-House” – A Web-based Collaborative Design Process

Miscellaneous small companies are offering a common service: A single-family house (“e-house”) that could be described as a prefabricated structure made out of, for example, wooden-elements. The design and the production process is a collaborative one. Therefore a virtual working environment is created. The participants inside the collaborative working group are the members of the design and manufacturing group.

The client, who is willing to order and buy the “e-house” is entering a web-based platform, which is connecting him to all members of the group. Specific tools are providing the possibility of easily creating a three dimensional structure, which is at the same time “visible” to all involved participants of the future building-process. Client and group members meet each other at the virtual working environment. Additional participants in the construction process will get in touch with the team via a virtual conference-room for ongoing exchange of information. When the design process is completed, the three dimensional information is going to be converted and split into single information packages allowing to calculate and manufacture the construction and cladding parts for the house. All assembly and finishing works are connected to the originally created model of the house.

Entering the virtual working environment, the client is able to control the design, the timetable as well as the building-costs.

### **Business Scenario: A “Collaborative Remote Decision System”**

The remote decision system is about problem solving directly at the construction site. It provides the possibility of digital-communication between diverse participants. For example: Mr X (site manager) is responsible for the refurbishing of an office building. During one of his periodic visit at the construction site, he identifies an unexpected structural problem that requires the advice of a technical expert. Using his PDA (or smart phone), he launches his favourite collaborative tool (for PDA) and, through the presence search service, gets in touch with the architect of the project (Mr Y) and one person of the structural team (Mr Z) at their respective office, both equipped with desktop computers and the same collaborative platform (for PC). The system establishes a virtual meeting between all of them.

Mr X exposes the problem (audio communication), takes a photo (or a video) with his PDA and sends it to Mr Y and Z. At the office, Mr Z asks the project server (seamlessly accessed from the collaborative environment) to download from the project repository all the documents related to the location where the problem occurs (detailed plans of the existing building and of the new project, technical documents...). Comparing the data for the existing building, and the photo sent by Mr X, he concludes that the data were not up to date, and that the new project should be modified. Having no personal solution to the problem, Mr Z questions a best practice database (through appropriate metadata or by submitting the photo for searching similar problems). This database is operated by the “Structural Engineers Community” he is belonging to. Having an answer to the problem, Mr Z asks the system to share his graphic viewer with Mr Y in order to show him the proposed solution. At the same time, consequences on site organisation and work scheduling can be analyzed through appropriate web services that are called on demand and shared between Mr Y and Z (including advanced 3D and 4D visualisations). Any interaction made by Mr Y or Mr Z with the shared applications can be seen simultaneously by both actors. The decision is made on the agreed solution. New plans are drawn; timetables are updated, and transferred to Mr X in a “lighter” version automatically built by the system accordingly to the display capabilities of Mr X’s device. The communications are finally switched down.

## **Roadmap**

### **Objectives**

Develop services and ICT tools to support optimised and dynamic steering of projects and decision support, both for management of construction processes (e.g. decision support system for priorities and impacts of risk mitigation) or for complex engineering problems (e.g. prediction and simulations tools for hazard impacts to the built environment in various conditions). These will rely on knowledge representation (models & standards for knowledge sharing like ontologies and semantic graphs), embedded learning support & training tools, Intelligent design & configuration tools, analysis, simulation & visualisation tools.

Develop new concepts and tools for Communities of Practice (CoPs) and Communities of Interest (CoIs) for Semantic Collaborative design and engineering established on common ground and shared understanding in the context of complex design and engineering tasks. The objective is the elaboration of ICT-based parametric open platforms offering knowledge semantic information space for communities at the crossing of design & architectural domain, engineering domain, semantic knowledge technology, promoting a better understanding, a closer dialogue and active cooperation between end-users/practitioners and solution/technology-suppliers through community building activities, and leading to reduce the concepts formalisation phase and improve considerably trade-off and decision support by a semantic based reasoning approach.

Therefore the development of translators and interfaces between applications and standard data presentations (e.g. IFC) has to be generalised, object databases (e.g. product / component libraries) and Model servers for sharing product model data, and models and ontologies to cope with any levels of semantics. Research should be pursued on the fields of:

- Model mappings & generalized ontology interoperability<sup>12</sup>;
- Increased intelligence of applications and interfaces for communication with other applications;
- Extensible models through metamodels enabling flexible extensions to standard models based on specific needs not covered by the standards;
- Model checking for validating model data against standards, regulations, design rules, contracts etc., with possible notification of identified conflicts and, when possible, suggesting corrective measures.

## **Main Research Areas**

### **Short term:**

- Take up of existing collaboration tools (CSCW, EDM/PDM).

### **Medium term:**

- ICT infrastructures and tools to support project collaboration of temporary multi-organisational teams.
- Integration of (internal) engineering & enterprise systems (CAE, ERP etc.) with (external) project collaboration environments in a transparent way including authentication, authorization and audit trail.
- Collaborative inter-enterprise ICT infrastructures including model and catalogue servers.
- Standardisation of the interfaces between enterprise systems and project collaboration environments.
- Collaborative ICT tools for information sharing, change management, project steering, negotiations, decision support, risk mitigation, on-site monitoring etc.
- Low entry tools for efficient integration of SMEs in project collaboration.

### **Long term:**

- Ubiquitous access interfaces for communication and information sharing with all stakeholders towards the merging of: "digital site" + "virtual project office" + "virtual control room" + "virtual service centre".
- Legal & contractual governance of shared object data.

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<sup>12</sup> Also in relationships with the “*Knowledge sharing*” roadmap.

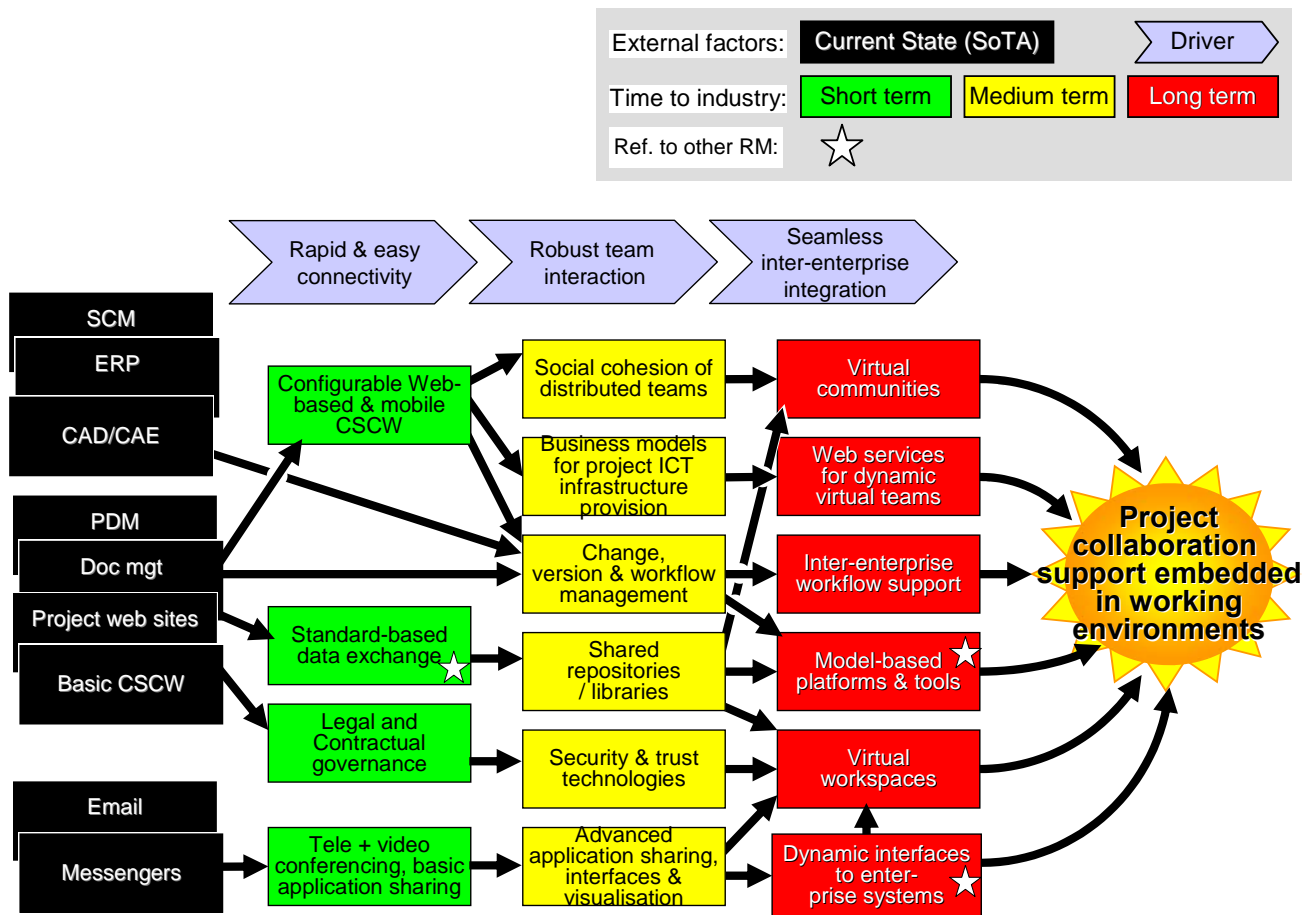


Figure 15: Roadmap for Collaboration Support

### Current State of the Art

- **Email:** Transmission of messages (text and files) over communication networks, mostly Internet. Very popular and the main information exchange in the Construction industry.
- **Messenger:** Synchronous mailing service that mainly provides instant transfer of messages and voice chat service. Still limited but spreading use.
- **Document Management Server:** System mainly used for exchanging and storing files (documents).
- **Project Web Site:** besides providing a place for exchanging and storing project-related documents, a Project Web Site includes other functionalities for asynchronous collaboration between distributed teams, e.g. (limited) workflow management, visualization of documents, actors' profile management, scheduling management, events follow-up, etc. However, its use is still limited to large projects because of the learning and parameterisation costs.
- **PDM (Product Data Management):** systems allowing the management of thousands of heterogeneous data (CAD/CAM data, Bills of Materials, etc.) related to products. In particular, technical data management permits the management of the all-informational patrimony of a product starting from its design until its discharge. Today, in the construction industry, the use of PDM systems (with the meaning it has in the mechanical industry) is very limited. But CAD systems (especially with import/export functionality in STEP/IFC format) can be seen as a kind of (partial) implementation of PDM for the purpose of concurrent engineering.
- **Basic CSCW (Computer-Supported Cooperative Work):** groupware-like systems that provide basic groupwork support services like file repositories, calendars, discussion forums, email distribution lists, partner contact information...
- **ERP (enterprise resource planning):** A business management system that integrates all facets of the business, including planning, manufacturing, sales, and marketing. As the ERP methodology



has become more popular, software applications have emerged to help business managers implement ERP in business activities such as inventory control, order tracking, customer service, finance and human resources.

- SCM (Supply Chain Management): The control of the supply chain as a process from supplier to manufacturer to wholesaler to retailer to consumer. Supply chain management does not involve only the movement of a physical product (such as a microchip) through the chain but also any data that goes along with the product (such as order status information, payment schedules, and ownership titles) and the actual entities that handle the product from stage to stage of the supply chain. There are essentially three goals of SCM: to reduce inventory, to increase the speed of transactions with real-time data exchange, and to increase revenue by satisfying customer demands more efficiently.

### Time to Industry: Short term

- Tele and video-conferencing: teleconferencing tools with audio and video using medium to high speed data connections (over Internet) allowing to develop shared multimedia communication environments between distant users.
- Configurable web-based & mobile CSCW: CSCW environments that support advanced cooperation functionality (e.g. application sharing, virtual meeting room) between distributed users, including mobile users, by taking advantage of the increasing bandwidth of communication channels. Seamless integration with user applications tends to develop (e.g. “Collaborative” AutoCAD).
- Standard-based data exchange: problems of interoperability tend to disappear thanks to a widespread use of data exchange standards such as IFC. This also allows to go beyond exchange of drawings and to foster the use of the digital mock-up.
- Contractual governance: contract-based mechanisms/procedures to practically set up the ways of ICT-based collaboration between partners. Need for contract models agreed by the construction industry.

### Time to Industry: Medium term

- Social cohesion of distributed teams: methods and tools to support the emergence of communities of practices (for instance SME networking), e.g. thanks to shared/distributed authoring using tools such as WIKI and the maintenance of emerging, specialized ontologies. Emergence of collective knowledge.
- Business models for project ICT infrastructure provision: new organisation patterns to support temporary, distributed, cross-organisational project teams with an economic viability.
- Change, version & workflow management tools: to allow the follow-up of the history of a project (successive versions, events, decisions, etc.), including the traceability of decisions with an objective of knowledge capitalisation, decision support and risk mitigation.
- Shared repositories / libraries: information/knowledge repositories that are not only internal to enterprises but shared (and above all updated and improved) between several stakeholders. (Linking to “knowledge sharing”).
- Security & trust technologies: advanced communication technologies that allow trusted relationship through authentication, security and confidentiality of information exchanges over all types of communication networks.
- Advanced application sharing interfaces & visualisation: communication tools that allow common use and exchange of data, including a suitable representation, continuously synchronizing the actual standard of knowledge of involved project partners.



## **Time to Industry: Long term**

- Virtual communities: Methods & tools to support more dynamic collective innovation of organisations relying on community-based forms of collaboration, e.g. using sophisticated applications based on WebDAV (Web-based Distributed Authoring and Versioning).
- Web services for dynamic virtual teams: ICT collaborative environments that allow to control and coordinate resource and service sharing to enable dynamic networking of virtual teams (presence, awareness, service discovery, ...) and provide adaptive context-aware and construction-specific web services that foster collaboration over time and space within and between organisations or communities. Include service composition.
- Inter-enterprise workflow support: solutions to achieve dynamic (“on-the-fly”) inter-enterprise workflow management based on business process models. Typically workflow applications/services are provided by the collaborating enterprises and can be accessed in the form of web services.
- Model-based platforms & tools: all data exchanges, processes and decisions are based on a shared building information model that covers all AEC/FM areas and enables process automation, systems integration, many different computer simulations & analysis, and user/context specific presentations/views. RTD in construction should skip over the existing PDM generation (which are rarely used today in construction), and focus on developing the next level technology, i.e. model servers that support collaboration, flexible work flows, change management, etc. in dynamic project consortia. Useful lessons can still be learned from current PDM as a baseline and for developing the migration strategy. Other industry sectors are moving from rigid supply chains to flexible & networked organisations. They are approaching a similar situation as construction from the opposite direction. This ongoing transformation of EU industries gives opportunities for cross-sectorial RTD where construction can provide added value and play a significant role.
- Virtual workspaces: advanced ICT-based environments that allow distributed team members to fully collaborate across organizational, geographical and time boundaries as if they were co-located. It implies excellent audio and video quality in communication for any kind of device and network, excellent presentation techniques, images and visualizations, intuitive interfaces and also expressive human interaction.
- Dynamic interfaces to enterprise systems: solutions to achieve dynamic exchange of information/data between miscellaneous enterprises and their individual systems.

## **Business Impacts**

ICT-based services and applications aiming at supporting BPM & BAM (Business Process Management & Business Activity Monitoring) in the Construction sector, through their various integration and the specific use of Dashboards (managing indicators, events, rules and administration of profiles) along with common repositories / Master data management. The use of such services / applications should first be experimented before generalisation / customisation and deployment.

As regards *Communities for Semantic Collaborative Design & Engineering*, the ambition is to develop and sustain a movement throughout Europe towards more dynamic collective innovation of European organisations and SMEs relying on revolutionary community-based forms of collaboration. The expected impact is an improved participation, and effective involvement and collaboration of industrial organisations (both institutes/academia and companies – especially small and very small – in closer relationships) in semantic collaborative modelling, design and engineering research activities, in the context of semantic rich environments with shared semantically described engineering concepts in the Construction industry.

## Thematic Mapping and Further Information

FP7 Information & Communication Technologies	<p>Software, GRID:</p> <ul style="list-style-type: none"> <li>• Collaborative approaches.</li> <li>• Simulation, visualisation, interaction &amp; mixed reality:</li> <li>• Tools for innovative design &amp; for creativity in products and services.</li> <li>• Knowledge, cognitive &amp; learning systems:</li> <li>• Interpret, represent &amp; personalise knowledge.</li> </ul>
FP7 Nanosciences, Nanotechnologies, Materials & new production technologies	<ul style="list-style-type: none"> <li>• Integration of technologies for new applications &amp; solutions responding to major challenges, as well as RTD needs identified by ETPs.</li> </ul>
ROADCON 2003	<ul style="list-style-type: none"> <li>• Adaptive and self-configuring systems.</li> <li>• Collaboration support for distributed virtual teams.</li> </ul>
ELSEWISE 1997	<ul style="list-style-type: none"> <li>• Communication network.</li> <li>• Coordinated ICT management in projects.</li> <li>• Groupware.</li> <li>• Multiple views.</li> <li>• Shared project database.</li> <li>• Workflow management.</li> </ul>
FIATECH 2007	<ul style="list-style-type: none"> <li>• Element 1: Scenario-based Project Planning</li> <li>• Element 6: Real-time Project and Facility Management, Coordination and Control</li> </ul>

## Roadmap: Knowledge Sharing

<b>Main Business Drivers:</b>	access to knowledge => sharing structured knowledge => context-aware knowledge
<b>Key Research Topics:</b>	ICT for transforming project experiences into corporate assets. Object repositories, IPR protection of complex shared data, context aware applications.

### Background

Experience and previous solutions are available in personal and departmental archives but new solutions are regularly re-invented in every project. The current background concerning the creation, capitalisation and use of “knowledge” can be mainly described as follows:

- Most information is stored in scattered archives, mainly paper-based, but in some cases digital. Content is not annotated, and is extremely difficult to find. Experiences from projects are not captured or retained efficiently and in most cases reside in the minds of those involved in the project. There is little, if any sharing or propagation of knowledge.
- The current collaborative environments ("project web sites") provide basic file/document management and basic collaboration tools. These kinds of tools / environment become more and more used, and can be considered as a very preliminary level of knowledge access and sharing.
- Even if the sector makes wide use of commonly available knowledge, few organisations exploit project experiences for developing genuine competitive advantages.
- Generic Knowledge Management has been a target for exhaustive RTD so far. However, very little has been done for capturing project experiences and targeted best practices, formalizing them into corporate assets and exploiting them in new business models. This remains a relevant opportunity for construction and faces little competition on RTD funding from other sectors.

### Vision

#### Target State

There will be a capability to support the sharing of previous experiences, good practices and knowledge within and, increasingly, between organisations. The aim is to have (transparently) immediate access to the right information, at the right time, in the right format, and from the right sources (both internal to an organisation and external). This encompasses also the achievement of tools / services and environment allowing sharing previous experiences, best practice and knowledge within and, increasingly, between organisations. The ultimate objective is access to and sharing of semantic information resources, with:

- Knowledge embedded in management systems, products, services, software, digital models and catalogues;
- Automatic indexing of both textual and non textual content (e.g. multimedia resources, like photos or video);
- Search engine able to take into account the implicit knowledge / implicit environment of the users to enrich his search and gave him only the most relevant information according to his profile.

#### Business Scenario: Sharing Knowledge across Industrial Sectors

An individual faces a problem (e.g. leakage through the roof of a concrete basement due to excessive rainfall). His/her KM environment should be able to search across multiple data repositories, mine the relevant information (e.g. from potential similar problems or occurrences) and return the

potential solution(s) and relevant contact people. At the same time, it should have the capability through a combination of ontologies (or a meta-ontology) to exploit relevant content for identification through the semantic web and retrieval of the same into end-user applications using intelligent knowledge agents. The retrieved content may come from a different domain (e.g. aerospace) and relate to a different problem whose solution may yet be relevant and adaptable to the problem in context.

### **Business Scenario: Intelligent e-Catalogues for Design and Sales**

This scenario is focused on e-procurement of construction products. It allows the use of intelligent electronic catalogues to support both design and sales process. In the first case the designer wants to try different products in his/her project. In the second case, the salesman uses the catalogue to show different alternatives to his clients. The catalogues are compliant to a given standard (e.g. XML, RDF, OWL) and a given software tool is used to support all interactions. Tools that can be considered here are the following: catalogue server and taxonomy server. The former helps publishing the respective catalogues of product (standard-compliant); the latter supports the specification of the products and helps treating the queries properly.

### **Business Scenario: Conformance to Industrial Regulation**

This scenario focuses on Knowledge Management practices related to conformance to industrial regulation. It relies on a Knowledge Management tool which can use services provided by an Ontology Server. For instance, the project manager feeds the system with knowledge about regulations (for instance, the “url” of regulatory bodies). During a project, he is informed about the publication of new regulations and then he uses the KM tool to verify if his on-going projects have to be changed in accordance with the new regulations regarding accessibility matters for disabled people. The Ontology server can be used to represent, classify, index, retrieve, and update the knowledge about regulations.

## **Roadmap**

### **Objectives**

A key objective is the development of a comprehensive methodology, with an iterative and incremental approach driven by well-defined industry requirements, which can be utilized by Construction organisations to define a full-fledged KM strategic vision, including development of semantic information spaces. As a stepped process, the methodology will encapsulate:

- the analysis of recognised current KM (best) practices and the identification of KM requirements within an organisation and between several organisations;
- mechanisms to identify informal KM processes and practices;
- modelling techniques to represent both formal and informal KM processes and knowledge items;
- identification of both socio-organisational techniques and ICT supported techniques to stimulate a knowledge sharing and dissemination culture – with the view that incremental evolution of ICT solutions to provide KM enabling functionality is required rather than step change;
- delivery of appropriate KM evaluation metrics dependent on the socio-technical solutions selected.

Information or knowledge should be available anywhere and at anytime. This will be achieved through the development of ICT-based information repositories and services (including information retrieval and semantic search engines, as well as administration of profiles and access control conventions) providing ubiquitous access to both explicit *corporate* knowledge, and *domain* knowledge (e.g. standards, regulations, specifications, etc.), as well as to some explicit representation of tacit knowledge and skills of the company’s experts. This should be achieved through experimentations on top of various well-defined scenarios and with a constant will for adaptation to users practices

and needs, including multi-modal interfaces (voice, 3D, immersion, etc.) allowing to get rid of complexity of ICT systems.

## Main Research Areas

A wide range of different ICT based tools and services necessary for moving an organization towards a dynamic knowledge management will be developed in the next years. ICT should be essential not only for the storage of tacit and explicit knowledge in web based repositories but also as a communication device allowing ubiquitous access to organizational knowledge anywhere, anytime.

### Short term:

- Online knowledge repositories
- Shared ontologies
- Distributed content management systems

### Medium term:

- Knowledge/best practice repositories
- Semantic tools
- Knowledge management services, models, and frameworks
- Advanced decision support systems

### Long term:

- Knowledge mining and semantic search services and tools
- Adaptive and context aware applications

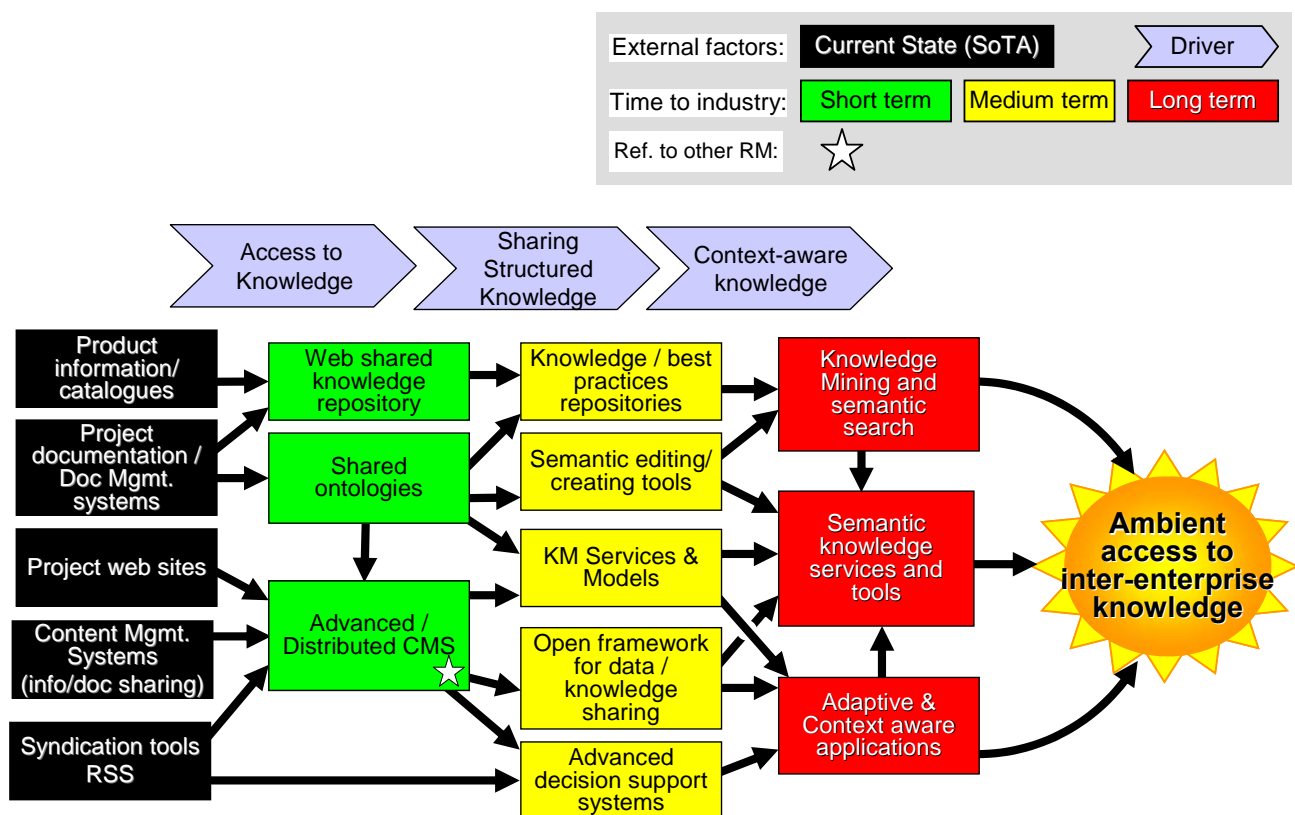


Figure 16: Roadmap for Knowledge Sharing

## Current State of the Art

- Product information: Product catalogues (electronic & paper based) mainly containing static textual information on products/services.
- Project documentation: Simple document management systems for archiving project documentation.
- Project web sites: Quasi static websites of a given project with limited groupware functionality.
- CMS: Content Management Tools: Content management systems are the next generation of simple document management systems. They offer the possibility for publishing information and sharing it across organisational units. Some groupware functionality is usually offered.
- Syndication tools (RSS): Aggregation of news flows on one single page, dynamically refreshed. This is just a tool to concentrate several information sources. A good example is “My yahoo”.

## Time to Industry: Short term

- Web shared information repository: Web space accessible to all through given rules (user rights management mainly), where information/knowledge can be stored / retrieved.
- Shared ontologies: Identification of key concepts and their inter-relationships. Ontologies should not be too generic or too large. Rather, lifecycle phases, or topic specific (e.g. facilities management) should be developed in detail. A meta-ontology should be built on top of these to allow for interoperability and mapping between these ontologies when and where needed.
- Advanced/distributed CMS: Dedicated solution, providing advanced services (profile and context based information push for instance). These solutions will also rely on open common agreed standards to exchange knowledge across different CMS.

## Time to Industry: Medium term

- Knowledge /best practices repository: Methods and tools for the identification, capture, consolidation, and dissemination of best practices. These should contain tools that enable the search and retrieval of past experiences, good (to-do) and bad (not-to-do).
- Semantic editing/creating tools: Tools that allow for automatic on-the-fly tagging of not only content (documents, drawing, media, etc.), but also parts of content (paragraphs, objects, etc.) based on shared ontologies. These should also support user-creating semantic links between different objects. Furthermore, based on a search, these tools should support content classification based on on-the-fly ontologies created through concept analysis from the searched content.
- KM services & models: These services should facilitate inter-enterprise knowledge management through provision of simple services such as searching, and sophisticated services such as e-Tendering. Models through the support of shared ontologies should support the classification and tagging of relevant content to projects, products, services, etc.
- Open framework for data/ knowledge sharing: Development of platforms and services dedicated to the knowledge sharing in inter-organisational environments. They are dedicated to knowledge sharing based on user profiling, and push of adapted/relevant information to each profile. These should ideally be transparent to the users and be accessible by different applications and search services. Furthermore, they should provide relevant groupware functionality at an industry (e.g. network of experts) level.



- Advanced decision support systems: The focus should be on support for real-time decision support as compared to decision support during planning phases only. Advanced decision support will be possible through a consolidation of the expertise (relevant experts) and various analytical tools based on past project performance. These tools should furthermore be supported by syndication services acting on business intelligence applications and sources.

### **Time to Industry: Long term**

- Knowledge mining and semantic search: Development of new searching methods and tools aiming at reducing the “noise” of the answers by taking into account the implicit environment in which the query has been submitted by the user. Searching capabilities will be extended to non textual content (multimedia formats). Tools for the retrieval of knowledge, business logic, and rules from different information sources and applications. This should be automated, with the captured business logic and rules made reusable in the form of application components.
- Semantic knowledge services and tools: Development of both meta repositories (that will provide definitions of, and relationships, and mappings between different information repositories, knowledge sources and ontologies) and semantic technologies being able to modify / adjust / enhance user’s queries so as to retrieve the required information from the relevant sources (taking into account, the implicit context of the query). As an example, knowing that the calling user/application is from the construction domain, when a search on “knowledge management” is done, the system would search for “knowledge management + construction industry”. Furthermore, the results may be ranked and categorised (automatically) based on the typical preferences of the user/application. One promising way to implement such tools is based on the agent technology.
- Adaptive & context aware applications: Development of self adapting tools anticipating user’s needs and actions (anticipation based on the treatment of information flows and internal knowledge and process models and rules) and presenting the “right functionality at the right moment”. They rely on user profiles, roles, etc. Ubiquitous, personalized and context-dependent access to knowledge is necessary and will be provided through ambient access technologies. These technologies will be based on an integrated use of ontologies, semantic web, context aware applications, knowledge processes, personal usage patterns, mobility, etc. This will enable a paradigm shift in the way individuals and mainly applications solicit information from the Internet. As opposed to human interpretable and computer uninterpretable web content, annotations and intelligence will be added to content to all for ease of retrieval and interpretation by different applications.

### **Business Impacts**

Intra- and Inter-company Knowledge Management will:

- Allow digital capitalisation of knowledge and experiences generated on construction projects to avoid repeated errors and increase quality of construction;
- Improve companies’ productivity and skills based on knowledge capture and transmission processes.
- Improve sharing of knowledge between enterprises involved in the building process, especially for the supply chain management, while preserving individual competitiveness.

Ambient access should allow a generalized use of digitalized information and knowledge throughout the whole company, allowing re-use of information and seamless access to the full expertise within the company, anywhere, anytime.



## Thematic Mapping and Further Information

FP7 Information & Communication Technologies	Knowledge, cognitive & learning systems.
FP7 Energy	Knowledge for energy-policy making.
FP7 Environment	<ul style="list-style-type: none"> <li>• Assessment tools for sustainable development (assessment of impacts of current trends in production &amp; consumption patterns related to Construction).</li> </ul>
ROADCON 2003	<ul style="list-style-type: none"> <li>• Adaptive and self-configuring systems.</li> <li>• Ambient access.</li> <li>• Knowledge sharing.</li> </ul>
ELSEWISE 1997	<ul style="list-style-type: none"> <li>• Enterprise models.</li> <li>• Learning organisation.</li> <li>• Re-use of prior knowledge.</li> </ul>
FIATECH 2007	Element 8: Technology & Knowledge-enabled Workforce

## Roadmap: ICT Enabled Business Models

<b>Main Business Drivers:</b>	business networking, customer orientation & sustainability, system integration, specialisation
<b>Key Research Topics:</b>	new ways for sustainable exploitation of ICT as a key part of business strategy in the open European / global construction marketplace; management tools and services to support inter-organisational collaboration across products and services

### Background

- The sector makes wide use of commonly available knowledge. Few organisations exploit project experiences for developing genuine competitive advantages.
- Current business processes provide low incentives for R&D and knowledge development.
- Current business model are based on lowest cost and capacity.
- Enlarging open market, evolving business processes and new technologies in combination open up rewarding opportunities to innovative companies to develop and offer new knowledge based products and services.

### Vision

#### Target State

- Innovative companies offer new knowledge based products and services in the construction sector based on: branding, business networking, ICT, innovation, knowledge, specialisation, system & service integration etc.
- New ICT enabled business models support advanced: business networking, customer orientation and sustainability, system integration, and specialisation allowing for on-demand customisation of products and services.

#### Business Scenario: Inter-organisational Competence Network

Organisations are part of a network that agrees upon certain rules for inter-organisational collaboration including shared standards, common or interoperable ICT tools, collaboration platforms etc. Participation in the network is based on complementary competencies and not necessarily capacity. When a client approaches one organisation with a request for a unique product or service, the organisation using an intelligent competency search and assimilation tool, relies on the network to build a consortium based on required competencies. The consortium can be self-configured in terms of participants, competencies, roles, etc. and a collaboration solution configured based on the unique needs of the project. A virtual enterprise is created, configured and put in operation to deliver the product/service. When the product/service is delivered, the virtual enterprise is decommissioned (or a new one formed to provide lifecycle support for the product/service).

#### Business Scenario: Plug & Play Building Design

A user would like to design his/her dream home. Through plug and play product/service components, the user can design and digitally assemble the home based on a set of generic components. For each of the components, relying on searchable and comparable product catalogues, a user can select different product component solutions from different manufacturers/suppliers. The home is automatically designed based on smart connections between the different components. A cost and schedule estimate is also generated on the fly within a margin of error of 15-20%. The user can fur-

thermore based on the design and selected components identify relevant contractors to build the home.

### **Business Scenario: Total LC Mgmt. from Conception to Demolition**

Clients' expectations and needs are captured and validated very early in the process. Visual information is used to inform the client about the project and also on previous similar developments. The expected TLC performances are defined at the beginning of the design phase and used, as inputs, to optimise different technical domains. Optimisation uses on-line information about building components. On-line geographical information is accessed to test implementation options and to require planning permission from authorities. During the design phase, simulation is used extensively to test "what-if" scenarios and to assess feasibility and buildability. Planning and cost estimations are conducted concurrently with the design. Long term partnering relations allow to simplify the procurement phase and to start the construction phase. The "design product model" is used on site through wearable and wireless computing and is updated regularly (along with planning and cost estimates) with "as built" information. Delivery information of components and materials is accessed on-line and in real-time to prepare site for deliveries. "How to build" information is checked on site through visual displays by subcontractors in order to avoid errors. At the end of the construction phase, an "as built" model is handed over and used for FM and for automatic generation of maintenance schedules. After demolition of the building, dangerous materials are tracked and oriented toward adapted facilities.

## **Roadmap**

### **Objectives**

Develop:

- Model based services offering new business opportunities enabled by model based data e.g. analysis, estimation, visualisation, simulation etc. Thanks to computer-interpretable information highly specialized services using sophisticated software become feasible.
- Model driven process / workflow management, leading to intelligent workflow aid combining product model with scheduling, resource planning and progress monitoring.

### **Main Research Areas**

The ICT-based solutions should be, among others:

- Innovative e-Business solutions, especially for SMEs, supported by open, interoperable, modular and adaptive ICT-based platforms that would also allow integration of enterprise applications.
- Pan-European multi-lingual "information resource points" accessible and "valuable" all across Europe. This will be done through the promotion of the semantic web and its related technologies applied to the Construction needs.
- Solutions for Sustainability management, through optimised management of multi-constraints systems, and improved cooperative development towards "sustainable construction model(s)".

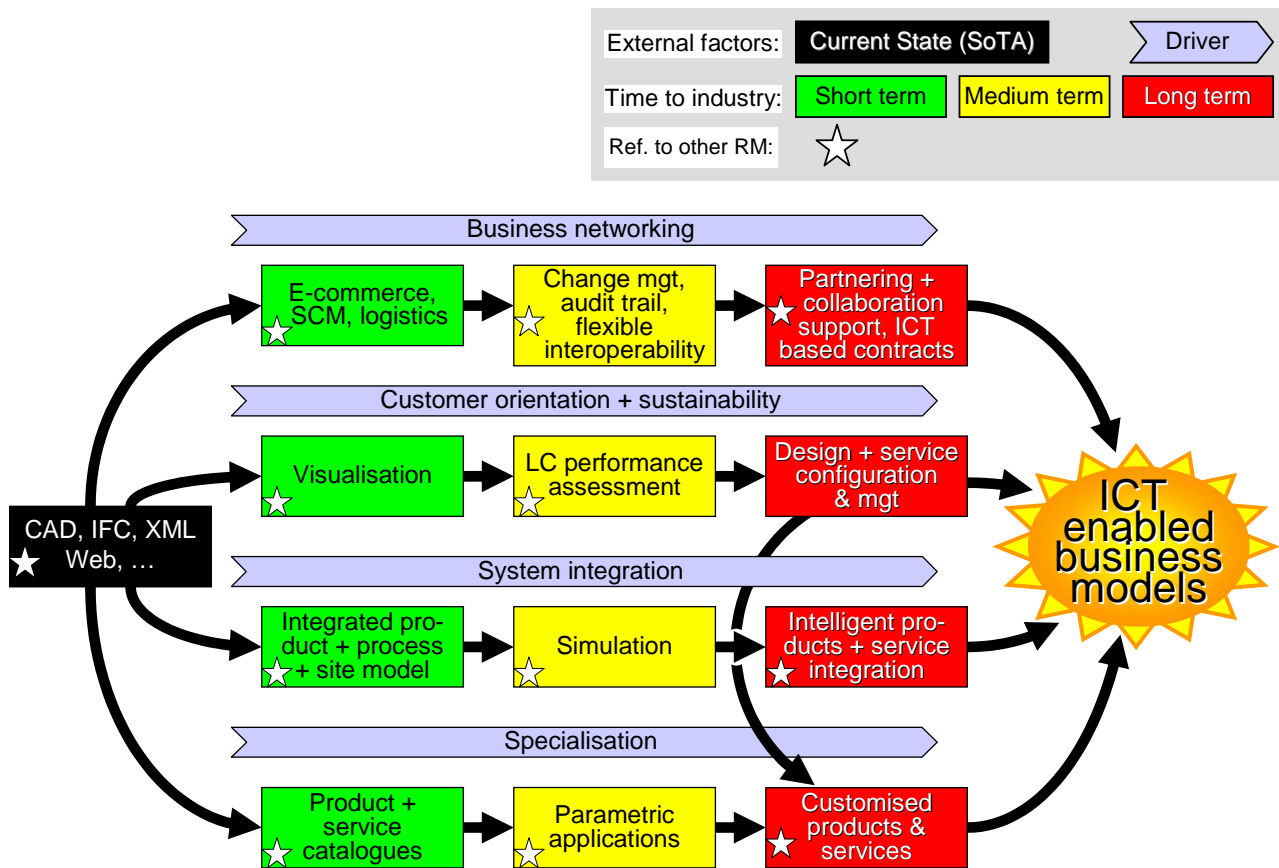


Figure 17: Roadmap for ICT enabled business models

#### Short term:

- Tools for managing inter-functional and inter-organisational e-Commerce, supply chain management, and logistics
- Tools that support product, process and service visualisation
- Tools that support management and integration of products, processes, and site models
- Tools for managing (digital) product and service catalogues

#### Medium term:

- Tools for managing change management, audit trailing, and flexible interoperability in inter-organisational settings
- Tools for managing life-cycle performance assessment
- Tools for managing product and process simulation
- Tools for managing parametric products and services

#### Long term:

- Tools for managing partnering, collaboration support, and ICT based contracts in inter-organisational settings
- Tools supporting both design and service configuration and management
- Tools for managing intelligent product and service integration
- Tools supporting product and service customisation.

## Current State of the Art

- CAD, IFC, XML, Web, etc.: Technologies currently used are most of the time CAD tools and Office tools, with limited integration and interoperability (even if some of those tools provide file exchange mechanisms, e.g. the IFCs, and/or APIs for integration), and very few of them really object-oriented. These tools typically support a particular operational phase or product/process domain.

## Time to Industry: Short Term

- e-Commerce, SCM, logistics: e-Commerce, supply chain management and logistics is typically limited to uni-directional flow of products and related information. New business models should concentrate on multi-directional flow of information throughout a given product or services life-cycle. While a product or service may flow from one organisation to the next, and then yet to another within a typical supply chain, there is a need for information relay across all organisations involved in the chain. Tools that support the management of inter-functional and inter-organisational e-Commerce, supply chain management, etc. need to be developed.
- Visualisation: Product (and increasingly service) visualisation is allow to support customers' understanding of the product/service that they desire. A simple example is a 3-D walkthrough a to-be-built building. In addition to product geometry visualisation tools will support visualisation (e.g. in the form of a management dashboard) of schedules, cost, product performance, etc. at any given point in time (before, during, and even after construction of the physical product).
- Integrated product + process + site model: Management tools that will support visualisation and management of different building model views such as product, process, and site views (models). These could be in the form of visual information layers that provide related information on an object (e.g. a beam) from a product, process, or site perspective at a given time. Such tools will (at least in part) rely on the IDM (information delivery manual) work being done by the IAI (More information available at <http://www.iai.no/idm/>.)
- Product + service catalogues: Product and service catalogues will allow provide product and service information in a digital form. This will allow for use of this information in different design/management applications and furthermore allow for comparison of similar products and services from different manufacturers and suppliers.

## Time to Industry: Medium Term

- Change mgmt, audit trail, flexible interoperability: Business models and tools supporting inter-organisational change management, audit trailing, and flexible interoperability across distributed applications. These will allow organisations to monitor and track how their products/services may have been changed/modified through a typical supply chain. Accordingly, organisations will be in a better position to learn from the experience of others on “their” products and thereby present an opportunity for providing better, more configurable products and services in the future.
- LC performance assessment: A product or service can be best optimised in terms of value to the customer if its performance during different project life-cycle stages is assessed. This assessment can allow for product/service reconfiguration and optimisation for that particular lifecycle stage based on the stage's requirement and the then state of the product/service.
- Simulation: Product/service simulation for different project lifecycle stages under varying boundary conditions can support better understanding of product/process/service behaviour and thereby offer opportunities for improvement in real-life settings. It is important to note here that they key point is simulation under “different” boundary conditions which is a reflection of product/service behaviour under different usage scenarios.
- Parametric applications: Parametric applications will support the design, assembly, configuration and management of products/services through their product and service catalogues. These

parametric applications will increasingly rely on ontologies and semantic services for assembly, configuration, and management of different components (possibly dissimilar and from different manufacturers/suppliers) of products/services.

### Time to Industry: Long Term

- Partnering + collaboration support, ICT based contracts: Organisations that are a member of a network that share common standards, interoperable ICT tools, etc. will be able to quickly set-up collaboration spaces to share competencies to deliver unique one-of-a-kind products and services. Increasingly, based on the product/service components provided by the different organisations and the nature of the project at hand, ICT based (electronic) contracts will be negotiated through applications with final endorsement from the participant organisations. Legal barriers such as legal admissibility of emails, CAD drawings, use of ASPs, ownership of information, company vs. project information and legal issues of objects (such as IFCs) are overcome by specifying an ICT-related contract governing these issues. E-contracting, contract configuration and on-line negotiation tools) are used to develop such ICT-related contracts.
- Design + service configuration & mgmt.: Relying on lifecycle performance assessment (possibly through visualisation and simulation), new business models and supporting tools will allow for design optimisation, service configuration (based on optimal state of product or service at a given lifecycle stage based on functional needs of client), and management.
- Intelligent products + service integration: Intelligent products will be linked to relevant services based on semantic product definition allowing for look-up of related services, service providers, etc.
- Customised products & services: Product/service catalogues parametric applications will open new forms of business allowing customisation of products and services based on specific client needs. Relying on modular product and service design, customers will be able to receive the product/service that they desire through an assembly of a set of choice products/services. These can be designed, assembled and configured on demand based on intelligent connections connecting different product/service modules. Being modular in nature, the products/services can be changeable when desired as opposed to being built for life.

### **Business Impacts**

ICT-based services will enable companies to create competitive advantage through new operating models in several key areas. Some examples are:

- Logistics services focused on creating new operating models in the network level.
- Structured recording of experience and knowledge in order to improve information management, workflow management, interface management and document management.
- Risk management system including diagnostic and decision support tools that enable the identification, analysis, tracking, mitigation, and communication of risks in software-intensive programs.
- Design, configuration, and life-cycle management of one-of-a-kind products and services
- Real-time identification and assembly of competencies across organisations to support inter-organisational collaboration to deliver a customised product or service.



## Thematic Mapping and Further Information

FP7 Information & Communication Technologies	<ul style="list-style-type: none"> <li>• ICT for trust and confidence.</li> <li>• ICT supporting business &amp; industry: <ul style="list-style-type: none"> <li>– Dynamic network-oriented business systems for product &amp; service creation and delivery.</li> </ul> </li> </ul>
FP7 Nanosciences, Nanotechnologies, Materials & new production technologies	<ul style="list-style-type: none"> <li>• Develop/validate new industrial/business models &amp; strategies for whole Construction LC.</li> </ul>
FP7 Environment	<ul style="list-style-type: none"> <li>• Assessment tools for sustainable development (assessment of market-based &amp; regulatory approaches).</li> </ul>
ROADCON 2003	<ul style="list-style-type: none"> <li>• ICT skills and awareness.</li> <li>• Legal and contractual governance.</li> <li>• Total Life Cycle support.</li> </ul>
ELSEWISE 1997	<ul style="list-style-type: none"> <li>• Demanding client.</li> <li>• Differentiation.</li> <li>• Dynamic virtual enterprise.</li> <li>• Enterprise models.</li> <li>• Life cycle view.</li> <li>• New business concepts.</li> <li>• Total life cycle management.</li> </ul>

## Strat-CON: Key Lessons Learned

Some of the key lessons learned during Strat-CON in terms of roadmap development are summarised below:

- Roadmaps should be simple:
  - Each roadmap should fit on one slide and preferably contain no more than 20 elements (boxes)
  - Roadmaps should be supported through a set of viable business scenarios
  - Roadmap elements need to be supported through a set of strategic actions that serve as building blocks for projects contributing to realisation of the vision of a given roadmap.
- Roadmaps need to be regularly updated:
  - Roadmaps should be updated every 1-2 years to reflect advances in research and development at an international level
  - Mappings to different funding opportunities need to be updated every 4-6 months to reflect current availability of sources and topics for funding
- Roadmaps should provide an industry perspective:
  - They should indicate what the industry can expect in the short, medium, and long term
  - There is a need to mention the key role(s) that different actors from the industry need to play to contribute to the realisation of the vision
  - Key benefits to different stakeholders need to be highlighted at both roadmap and strategic implementation action levels
- Roadmaps serve as a common basis for:
  - What people have done
  - What people are doing
  - What people would like to do
  - Networking and dialogue around a particular theme

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## Appendix A: List of Strategic Actions

This appendix lists more than 180 different short, medium, and long term strategic implementation actions of interest identified through a series of more than ten workshops. The aim of the workshops was to first, understand the thematic roadmaps and to then for each roadmap identify a series of short, medium, and long term strategic actions (in terms of time to industry) that the participants had an interest in undertaking.

### Value Driven Business Processes

#### Short Term:

- Methods for assessment of value of an ICT (synthesis of value chain, process, and information flow models)

#### Medium Term:

- Performance ontology
- A KPI process and benchmarking model for clients (process models for each KPI, decision support system to evaluate product model)
- Construction customer needs analysis model
- IT enabled integrated construction processes (platform and methodology to manage construction “value” chain)
- Innovative tools for life cycle management
- Supporting citizen actions for energy efficiency in buildings.
- Human needs impact assessment
- Human happiness/well-being impacts on built environment
- Involvement of end user: requirement capture, configuration/customisation of product + service including value model
- Customer value patterns

#### Long Term:

- Visual integrated, holistic tools and methods to design, and maintenance solutions for life-cycle optimisation
  - Human activity enabling infrastructure
  - Value model driven business configuration
  - Holistic model + ontology of values-requirements-configuration-process-... indicators. Conflict requirements and resolution methods - Aligning requirements and solutions
-

## **Industrialised Production**

### **Short Term:**

- RFID for safety on site.
- Renovation: small scale / stepwise production.
- Werkbund production ecology.
- Review of state of the art + best practices
- RFID localisation + state of product
- Robotics and automation in industrial manufacturing
- Incorporation of ambient intelligence in construction industrialised products and systems
- Standardised production based on building product models
- Integrated building components
- Re-usable building components

### **Medium Term:**

- Component based localized production to minimize transportation. As built models. Interfaces. Tolerances. New materials. Simulation models.
- Component based configuration design & management.
- Life cycle component information.
- Printable / site-produced products.
- Open building systems (top down).
- Mobile production.
- Reusable components / information.
- Knowledge based collaborative production
- Intelligent product catalogues
- Wearable terminals->machinery instruction => (worker locations + safety info)
- Industrialised reference process and ontology
- Tools for mass customisation
- Dynamic planning, simulation

### **Long Term:**

- Community model: local providers, location based supply. Ambient production.
  - Ontology of building + supply + transportation. Multi-language reference ontology. Neutral XML description for search engine compatibility.
  - Redesign/optimisation of processes, products and materials for mass customisation + systems and architectures (centralised and localised systems)
  - Self-configuring networks
  - Impact of “things for construction”
-

## **Digital Models**

### **Short Term:**

- Model Interaction with mobile Devices
- Semantic Support for Appropriate Digital Presentation
- HVAC interface to product models
- Building physics simulation
- Time to market model
- Model-based decision support
- Right management of model objects
- All kind of applications: analysis, simulation, visualisation

### **Medium Term:**

- Domain Specific Functional Product Description
- PM Based Comfort Simulation
- New Approaches of Visualisation
- Standardised API to digital models
- Ontology based failures modes effects and criticality analysis
- Distributed simulation & testing (virtual labs)
- Process based access to product data
- Product based building construction process generator
- Human aided design models
- Merging of partial models
- Domain specific models and context based views
- Model change management

### **Long Term:**

- Impact of Digital Model Techs on Work Practice
  - Federated Model Servers
  - Digital model for LC assessment
  - Building model optimisation tools
  - Configurable building components
  - Real time model updating
  - De-centralised product catalogues
  - Mathematical solvers
  - Design and analysis automation
  - Building model knowledgebase
  - Distributed model synchronisation
-



## **Intelligent Constructions**

### **Short Term:**

- Intuitive remote access to Construction data
- Active energy intelligent buildings
- ICT-based services for comfort at home
- ICT-based services for ambient assisted living

### **Medium Term:**

- Self-adapting built environments
- Responsive buildings to change of usage patterns
- Digital home platform and services
- Embedded sensors for the self environmental monitoring network in construction
- Standard protocols for plug & play of intelligent devices
- Building informing and engaging user in building monitoring and environmental
- Distributed architectures for automation and control

### **Long Term:**

- N/A
- 

## **Interoperability**

### **Short Term:**

- Extension of IFC: “ifc-road” “ifc-civil work”
- Methodology for describing quality assurance at an object level
- Integration of BIMS with city models (GIS)
- User guidance on BIMs and interoperability
- Transformation and check-in/check-out of data sets

### **Medium Term:**

- Digital framework for developing engineering models.
- Ontologies for objects with quantitative attributes.
- Ontologies for Construction rules & constraints.
- High level functionality (including consistency) on top of model servers.
- Domain-specific common transaction protocol.
- Integration of business systems/back-offices
- Neutral services acceptable to SMEs
- Web-based reactor agents

### **Long Term:**

- Cross-sectoral interoperability.
  - Product/Service information delivery supported by a semantic (Web) approach.
  - Catalogues of semantic interoperable business services
-

## **Collaboration Support**

### **Short Term:**

- Pervasive document and information sharing
- Visualisation interfaces for building / construction coordination
- Digital Passport (single logon)
- Project handbook: info management
- Requirement capture for whole lifecycle
- Organisation of project website contents
- In-house collaboration support systems for planning/designing
- Context based filtering of information overload
- Audit trails (log)

### **Medium Term:**

- A Project-oriented Virtual Meeting Point
- Network Building (virtual teams)
- To Find Human Resources at the Right Time
- Interoperability + data standard of Collaboration Systems
- "e-Dating" - e-Business platform for ad hoc Partnering
- Trust in collaboration
- Steering system for design process in architecture
- Virtual collaborative workspace for mobile workers
- Semantic collaborative engineering space
- ERP project room (Virtual company)
- Information for FM stage
- Communication between skill borders: visual, audio, etc.
- Visualisation of project stage, management information
- Transaction management systems
- Integration of IT+HR in change management towards collaborative working
- Collaborative engineering environment for multiple engineering disciplines

### **Long Term:**

- Transparent and personalised project information
- Standardisation of collaborative info/system interfaces
- Integration of end-user in process
- Intelligent objects (components) as a “physical-layer” of communication over lifecycle

## **Knowledge Sharing**

### **Short Term:**

- Competence/experience engine
- Classification based document tagging
- Construction industry meta-ontology
- Profile and context based content retrieval
- Industry-wide open knowledge sharing space
- IFC-based knowledge categorisation
- Body of knowledge for construction management
- Text to speech tools
- Experience handling at project enterprise, national, EU levels

### **Medium Term:**

- Content management system for knowledge transfer
- Tacit knowledge capture and facilitate (ontologies, rule automation, platform)
- Building memory (systematic capture and analysis of business performance ... learning from the building)
- Managing complementarity of projects and services (building performance improvement through ICT)
- Semantic discovery & integration of inter-enterprise services (discovery, configuration, model based services, horizontal ontologies)
- Semantic search framework for AEC
- Shared knowledge for efficient collaboration in construction
- Regulation awareness system
- model driven process configuration
- Knowledge based (rule based systems) engineering
- Performance (competence) based market research
- Interoperable knowledge classification systems

### **Long Term:**

- Tacit knowledge capture and articulation (framework, model, system)
  - Model based access to past project knowledge bases
  - Knowledge “flow” chain management
  - Context aware contract generator
  - Cross-sectoral semantic search
  - Knowledge based situation analysis
  - Context aware IPR management
  - Context aware access to model based interoperable knowledge bases
  - New ICT driven knowledge usage scenarios
-

## **ICT Enabled Business Models**

### **Short Term:**

- Shared purchase portals.
- Online building codes accessibility
- Language interoperability (IFD) [international framework for dictionaries]
- Improved case study representation of positive examples
- Make the state of the art of opportunities
- ICT-based services for customers comfort

### **Medium Term:**

- Legal structures. Trans-national business networks.
- Certified & guaranteed products by simulation / tools.
- Sell value/performance instead of equipment.
- Transferring long term responsibilities.
- User needs assessment extraction methods
- Better visualisations integrated impacts over time
- Remote management
- Service brokering
- E-market places for/with SMEs (online-dating)

### **Long Term:**

- Model driven business process configuration
- Product/service Google (e.g. start bank, Norway)
- Dynamic market simulation
- Better understanding of evolution of user needs & desires over time
- Rule based ontologies
- Tools to measure value & risk (e.g. for sharing benefits)
- Contract driven workflows
- Virtual enterprise configuration (both clients and suppliers)
- Branding
- Enterprise centric business models (opposite to project driven)

## Appendix B: Detailed Strategic Actions

This appendix presents more than 55 detailed short, medium, and long term strategic implementation actions for the eight thematic roadmaps. These detailed strategic actions are seen as possible building blocks for future R&D projects. For each of the eight roadmaps, a summary of all strategic actions is presented followed by their details respectively.

### Value Driven Business Processes

Strategic Action	Objectives
<b>Aligning Information Management with Client Values</b>	Clients demonstrating recognition of the value of developing a project information management strategy by its inclusion in initial value management workshops and subsequently, at the early stages of the project (at least Detailed Masterplan Stage), providing sufficient resource, authority and accountability (comparable to that provided within a company environment) to enable jointly developed performance measures to be achieved. Criteria, methods and tools for the interface between the project information management strategy and the project stakeholders' ICT and information management systems will be defined.
<b>Construction Customers Needs Analysis Model</b>	Model which enable to capture "client" needs taking into account there can be few decision makers (or those who influence decisions/users) with some of them being unaware of their needs.
<b>Decision Support System (DSS) for the Agenda 21 Deployment</b>	The main objective of the project refers to the development of a DSS to help urban planners with the evaluation, visualization and communication of the environmental impact of urban proposals. The DSS (Decision Support Systems) will consider: <ul style="list-style-type: none"> <li>• Energy consumption;</li> <li>• MSW (Municipal Solid Wastes) recycling;</li> <li>• Acoustic impact;</li> <li>• Air pollution.</li> </ul>
<b>Development of a global system for the prediction of sustainable impacts related to the construction and management of urban environments</b>	Development of a global system for the prediction of sustainable impacts (environmental, economical, social) related to the construction and management of urban environments. The system will include the necessary methodology and tools for the integration of all relevant stakeholders in the design, planning and management processes. Among the relevant stakeholders citizenship will be considered. This integration will be supported by other methodologies and tools for the "translation" of technical issues to a "common" language that makes possible to all stakeholders the knowledge of the relevance of different alternatives.
<b>KPIs Process and Benchmarking Model for Clients</b>	Defining clients perceptions of performance and formation of 'KPIs' and developing 'KPIs Process and Benchmarking Model' for construction clients. Developing right quality perception by defining critical KPIs and Process Model for evaluating life-long project success. The indicators from the firms will be further developed into a benchmarking KPI model.
<b>Models and Tools for Values, Requirements, Solutions and Processes</b>	A comprehensive set of conceptual models for value-driven building processes; A comprehensive set of software tools that support value-driven building processes.
<b>Supporting citizen action for energy efficiency in buildings</b>	We propose to develop a practical decision support system that will support its users, i.e., citizens in taking substantiated action for energy efficiency. It will allow them to prioritize and evaluate scenarios. With metrics as simple and wide-known as pay-back figures. This environment will, first, include a vast repository of possible interventions for <ul style="list-style-type: none"> <li>• Energy efficiency</li> <li>• Alternative energies</li> </ul>
<b>Schools for the Future</b>	<ul style="list-style-type: none"> <li>• Provision of a future-oriented learning and teaching environment</li> <li>• Reduction of the energy consumption of schools (new and existing) with at the same time improved comfort (IAQ, lighting, etc.)</li> <li>• Using the schools as "living" show examples for increasing the awareness for energy efficiency of the pupils, the parents and the whole society</li> </ul>

## Aligning Information Management with Client Values

Keywords	ICT, Value, Client, Information Management									
Relevant to programme(s)	X	ICT			X	ERABUILD				
Time to industry	X	Short term				Medium term			Long term	
Topic area	X	1. Value-driven business processes								
Industrial problem / relevance	In the old world it was possible to learn faster than the world was changing, but in the new world the world changes much faster than our ability to learn. This is reflected in the construction industry where research in ICT applications is outstripping the industry's ability to implement them as part of a project information management strategy and understand the added value* they bring. <i>*Value is defined as (Benefits – Sacrifices) / Resources</i>									
Technological objectives	Clients demonstrating recognition of the value of developing a project information management strategy by its inclusion in initial value management workshops and subsequently, at the early stages of the project (at least Detailed Masterplan Stage), providing sufficient resource, authority and accountability (comparable to that provided within a company environment) to enable jointly developed performance measures to be achieved. Criteria, methods and tools for the interface between the project information management strategy and the project stakeholders' ICT and information management systems will be defined.									
Approach	An initial review of value management techniques (e.g. VALiD, Be Valuable) should be undertaken to understand current practices and how these can be augmented to incorporate information management and ICT applications. Criteria and metrics to quantify and measure the added value which information management and ICT brings will be developed. Dissemination of the results should build on these techniques and established audiences.									
Results	This work should bridge the gap between other ICT based proposals within this focus area and the informed uptake of their results within the industry environment. Established value management techniques will be extended to include methods for aligning ICT systems to the client's values and a systematic measurement framework to identify and analyse the resulting key performance indicators.									
Exploitation	Alignment with existing dissemination mechanisms (e.g. Constructing Excellence in the UK) to inform established audiences through adding content to introductory value management workshops and undertaking demonstration projects.									
Impacts	Effective exploitation of information technology as an enabler to support the achievement of client's values. This should result in the reduction of wasted resource which in the USA has been estimated to be \$15.8 billion per year (NIST GCR 04-867).									
Follow-up actions	Ongoing alignment of ICT research within this focus area to contribute to and fit within the value measurement framework.									
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## Construction Customers Needs Analysis Model

Keywords	capture customers chain and their needs				
Time to industry		Short term	x	Medium term	Long term
Topic area	x	1. Value-driven business processes		x	8. ICT enabled business models
Industrial problem / relevance	<p>Decision process in construction sector is complex process. Sometimes it is difficult to define who is a user/client/decision maker. Often all those different actors are user but their needs are different. If contractor will have a tool to analyse all those needs it could create new value [added value] in construction process. Good analysis of different users needs may lead also to innovation. Main problems:</p> <ul style="list-style-type: none"><li>• Difficulties with definition of clients/end users/decision makers in construction process</li><li>• Problems with identifying and understanding client/user needs?</li><li>• Where different users are involved company has a problem in definition and analysis of different groups needs</li></ul>				
Technological objectives	Model which enable to capture “client” needs taking into account there can be few decision makers (or those who influence decisions/users) with some of them being unaware of their needs.				
Approach	<p>Building business models for each of users and their needs, compare – analysis of different factors.</p> <p>Social studies + ICT tools</p> <p>Involvement of final users [ contractors] and their clients for tests.</p>				
Results	<p>New type and quality of services offered by contractor</p> <p>Knowledge based construction</p> <p>New opportunities by analysis of users needs [also for manufacturers of products]</p>				
Exploitation	To be used by contractors, ICT companies as external service, or on line web based tool				
Impacts	<p>New type of service [added value] offered by contractor</p> <p>Social impact as new wider type of needs will be take into account within construction process</p>				
Follow-up actions	<p>Business models developments</p> <p>Potential to link with other ICT tool – to create complex service</p>				
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### 1.3 Decision Support System (DSS) for the Agenda 21 Deployment

**Objectives:** The main objective of the project refers to the development of a DSS to help urban planners with the evaluation, visualization and communication of the environmental impact of urban proposals.

The DSS (Decision Support Systems) will consider:

- Energy consumption.
- MSW (Municipal Solid Wastes) recycling.
- Acoustic impact.
- Air pollution.

The DSS will be based on:

- Digital models of the urban environment.
- Heuristic environmental simulators which will be operative without huge amount of data.
- Communication and citizens participation strategies.
- Advanced visualization techniques (virtual reality, ....).

Final objectives of the project are:

- Reduction of resources consumption at urban scale: energy, water, fuel, raw materials,...
- Reduction of contaminated emissions: greenhouse gas, atmospheric pollution, acoustic emissions,...
- More habitable cities.
- More realistic and achievable Agenda21 action plans.
- Higher involvement of the citizens in their city planning.
- Affordable for small and medium cities.

**Scope:** The project will be developed on the framework of the urban development and management aiming to help urban planners in the decision taking and in the monitoring of actions plans in relation to integrated urban environment impacts.

**Proposed funding instrument:** STREP

**Tentative budget:** 3 M€

**Additional partner organizations needed:** *[branch]*

- High-Tech Enterprises focused on the creation and management of urban digital models.
- High-Tech Enterprises focused on the development environmental simulators.
- High-Tech Enterprises focused on the development of advanced interactive systems.
- High-Tech Enterprises focused on the in development of CSCW (Computer Supported Collaborative Work) tools.
- Enterprises focused on the municipal consultancy.
- Municipalities.
- Urban planners.
- Large promoters.
- ICT technologies providers (Research Centres and Universities).
- Environmental technologies providers (Research Centres and Universities).

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## Development of a global system for the prediction of sustainable impacts related to the construction and management of urban environments

**Objectives:** Development of a global system for the prediction of sustainable impacts (environmental, economical, social) related to the construction and management of urban environments. The system will include the necessary methodology and tools for the integration of all relevant stakeholders in the design, planning and management processes. Among the relevant stakeholders citizenship will be considered. This integration will be supported by other methodologies and tools for the “translation” of technical issues to a “common” language that makes possible to all stakeholders the knowledge of the relevance of different alternatives.

### **Scope:**

The global system will integrate:

- The whole life cycle of the urban environment: Design, construction, use and management and end of life of the urban environment.
- The relevance of the decisions and the planning in relation to environmental, economical and social impacts.
- The voice and the participation of different stakeholders involved on the decision taking, the planning and the management of the urban environment

The project will allow:

- The analysis of the sustainability of different action alternatives.
- The proposal of alternatives to increase the sustainability of new designs
- The proposal of actions to correct “mistakes” in certain urban environments
- The development of strategies of stakeholders cooperation developing tools to facilitate this cooperation (for instance, tools for “translation” of technical issues to a “common” language that makes possible to all stakeholders the knowledge of the relevance of different alternatives). Citizenship is included on this approach.

### **Proposed funding instrument:**

STREP

### **Tentative budget:** 3 M€

### **Additional partner organizations needed:** *[branch]*

- Specialist in urban economy
- Administrative bodies in charge of urban planning
- Urban simulators

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**KPIs Process and Benchmarking Model for Clients**

Keywords	Construction, Key Performance Indicators, Benchmarking, Clients					
Time to industry		Short term	x	Medium term		Long term
Topic area	x	1. Value-driven business processes				
Industrial problem / relevance	In the construction industry, competition is very thorough and therefore needs proper evaluation methods/models. In defining KPIs process and setting targets, clients can aim to meet those set in over the period of their programme of continuous improvement. Achievement of succesful projects will be gained by adoption of benchmarking from the best practices in the world. This project will produce KPIs providing the mechanism for clients to aspire to have more succesful projects.					
Technological objectives	Defining clients perceptions of performance and formation of ‘KPIs’ and developing ‘KPIs Process and Benchmarking Model’ for construction clients. Developing right quality perception by defining critical KPIs and Process Model for evaluating life-long project success. The indicators from the firms will be further developed into a benchmarking KPI model.					
Approach	Process model for each KPIs Cluster/factor analysis Decision support system as a product model					
Results	Process Models (for decision makers) for each KPIs Decision support system as a product model Benchmarking Model for comparing projects					
Exploitation	Listing the KPI’s for an end product and a model for evaluating them. KPIs Process and Benchmarking Model will be used for, Business performance improvement Best value procurement Selection of professional teams (subcontractors, suppliers, consultants etc.) Competitor comparisons					
Impacts	Change in behaviour of the firms during the decision making process to evaluate the end-products. Can be used as selection and system for clients. Determining the performance perceptions clearly for client and using of measured indicators. Internal and External Benchmarking Model will help developing end product quality					
Follow-up actions	Development of business and evaluation models and defining KPIs. Take up of results by the selected firms.					
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## Models and Tools for Values, Requirements, Solutions and Processes

Keywords	Value Models, Requirement Models, Requirements and Solutions, Product & Process Modelling						
Time to industry		Short term			Medium term	X	Long term
Topic area	X	1. Value-driven business processes					
Industrial problem / relevance	The building industry is still suffering from the problems identified by e.g. Latham and Egan: high failure costs, lack of innovation, lack of trust between partners and little use of information technology. An important step towards improvement is the shift from orientation on lowest price to best value-for-money; in other words the shift towards “value-driven business processes”.  However, in order to make this step, new models and tools are needed. Most notably, models and tools are needed for:			Life-cycle value engineering; Performance and requirements specifications; The processes that link these concepts with each other and with existing building information models such as IFCs.  Such a set of models will provide adequate support for innovative “value-driven” building processes, based on collaboration and involvement of stakeholders/users through the value chain. Also it will enhance development of demand based solutions/products.			
Technological objectives	A comprehensive set of conceptual models for value-driven building processes;			A comprehensive set of software tools that support value-driven building processes.			
Approach	The R&D-approach will include the following aspects: Exploration of the Value concept (what is value, value classification, value-related processes, etc) and use-case scenarios (as a guideline and reference for further research and development); Development of a conceptual framework for value-driven building processes; Elaboration of conceptual models for values, requirements, solutions and processes, as part of the conceptual framework;			Development of a generic system architecture for value-driven building processes; Development of a set of supporting tools, using a rapid prototyping approach Test procedures and pilot projects in order to evaluate the developed tools and to prepare for wider distribution and implementation Use of existing and emerging technologies (ontologies and semantic web technologies, product and process modelling, nD modelling.)			
Results	A model/ontology framework for values, requirements, solutions and processes that can be used as a conceptual foundation for innovative value-driven building processes			Software tools based on this framework that provide adequate support for innovative value-driven building processes			
Exploitation	The conceptual framework will be disseminated through publication in conference papers, journal articles and possibly in a book;			The software tools will be either commercialized and sold by a software vendor or made freely available as open source software			
Impacts	The ultimate benefit will be better building processes, i.e. building processes in which more value-for-money is created for end users, other stakeholders and society. For the building sector it will enhance production of demand based products.						
Follow-up actions	Collaboration with related RTD-projects on national, European and international level						
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## Supporting citizen action for energy efficiency in buildings

<b>Keywords</b>	Energy efficiency in building; capture customer needs					
<b>Time to industry</b>		Short term	x	Medium term		Long term
<b>Topic area</b>	x	1. Value-driven business processes	x	4. Intelligent constructions	x	8. ICT enabled business models
<b>Industrial problem / relevance</b>	<p>It is widely acknowledged that the energy efficiency of our buildings is far from optimal; a fact that creates a burden for the citizen budget as well as stress for the environment, the greenhouse effect emphatically included.</p> <p>There are simple metrics, maybe a bit raw and simplistic, but nevertheless useful perhaps because of this simplicity. Yearly energy consumption (Kwh) per building cubic meter (m3) can range from anything between 10 and 40. While the local context may of course influence this figure it appears that in many cases there is no fundamental reason for such a great divergence. In other words, the inefficiencies observed are largely due to a failure to adopt environment friendly and economically wise practices.</p>					
<b>Technological objectives</b>	<p>We propose to develop a practical decision support system, that will support its users, i.e., citizens in taking substantiated action for energy efficiency. It will allow them to prioritize and evaluate scenarios. With metrics as simple and wide-known as pay-back figures.</p> <p>This environment will, first, include a vast repository of possible interventions for</p> <ul style="list-style-type: none"> <li>• Energy efficiency</li> <li>• Alternative energies</li> </ul>					
<b>Approach</b>	<p>Solutions will comprise technical information about the following sub-sections</p> <p>Modeling efficient energy consumption</p> <p>Modeling the user context</p> <p>Returning advice to the user</p> <p>Testing in real buildings</p>					
<b>Results</b>	<p>To secure wide applicability the system will be checked in all following buildings. We will primarily validate against the “retrofit” scenario, which is, as analyzed above, a clear super-set of the new building.</p> <ul style="list-style-type: none"> <li>• Apartment</li> <li>• Office</li> <li>• Shop</li> <li>• Commercial use (warehouse, etc.)</li> <li>• Detached home</li> <li>• University building</li> <li>• Hospital</li> </ul>					
<b>Exploitation</b>	To be used by contractors, ICT companies as external service, or on line web based tool					
<b>Impacts</b>	<p>New type of service [added value] offered by contractor</p> <p>Rising awareness of users/clients</p> <p>Rising usage of new technologies in energy savings in buildings</p> <p>Increased energy efficiency in buildings</p>					
<b>Follow-up actions</b>	<p>Business models developments</p> <p>Potential to link with other ICT tool – to create complex service</p>					
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## Schools for the Future

<b>Objectives: -</b> <ul style="list-style-type: none"> <li>• Provision of a future-oriented learning and teaching environment</li> <li>• Reduction of the energy consumption of schools (new and existing) with at the same time improved comfort (IAQ, lighting, etc.)</li> <li>• Using the schools as “living” show examples for increasing the awareness for energy efficiency of the pupils, the parents and the whole society</li> </ul>	
<b>Scope:</b> <ul style="list-style-type: none"> <li>• Planning, realisation and evaluation of future oriented school buildings (new and retrofitted): Showing examples for energy efficiency, comfort, teaching forms, etc.</li> <li>• Socio-economic analysis of the influence of optimised schools buildings on the performance of pupils and the transfer of the energy efficiency awareness into society</li> <li>• Optimisation of building and system technology, user behaviours and control systems for the specific use in classrooms and schools</li> <li>• Set-up of a benchmark system and a label for energy-efficient schools through out Europe</li> <li>• Creation of an information exchange platform between future oriented schools and those that want to learn from them.</li> </ul>	
<b>Proposed funding instrument:</b> EU-funds (projects with EC-contributions), industrial co-funding	<b>Tentative budget:</b> 250 M€
<b>Additional partner organizations needed:</b> <i>[branch]</i> <ul style="list-style-type: none"> <li>• - communities, esp. planning departments and school authorities</li> <li>• - international research organisations</li> <li>• - Socio-economic researchers</li> </ul>	
<b>Contact person:</b> <b>Name:</b> Hans Erhorn <b>Address:</b> Fraunhofer Institute of Building Physics, Nobelstr. 12, 70569 Stuttgart, Germany <b>Phone:</b> +49-711-970-3380 <b>Fax:</b> + 49-711-970-3399 <b>E-mail:</b> hans.erhorn@ibp.fraunhofer.de	

## **Industrialised Production**

<b>Strategic Action</b>	<b>Objectives</b>
<b>Incorporation of ambient intelligence in construction industrialised products and systems</b>	<p>To provide conventions and standards for connectivity, so that different industrialised systems may be combined to suit different requirements.</p> <p>To develop more sophisticated monitoring and control systems for construction equipment.</p> <p>To develop and integrate real time diagnostic system for the monitoring of the building (or part of it) under construction and of the materials in arrive at the building site.</p> <p>Feasibility study of the time to market for the developed technologies.</p>
<b>Utilisation of BIM in knowledge based production planning in construction project</b>	<p>In this project BIM model checking would be expanded to production issues with new checking rules. However, the biggest challenge here is to model the tacit knowledge involved with production planning and to develop the analysis methodology for checking the compliance or non-compliance.</p>

## Incorporation of ambient intelligence in construction industrialised products and systems

<b>Keywords</b>	Industrialized, products, systems, construction				
<b>Relevant to programme(s)</b>	x	ICT	x	Eureka	
<b>Time to industry</b>		Short term	x	Medium term	Long term
<b>Topic area</b>	x	2. Industrialised production	x	4. Intelligent constructions	x 5. Interoperability
<b>Industrial problem / relevance</b>	<p>Needs of improving efficiency on construction sites.</p> <p>Previous attempts to introduce industrialised construction methods failed because systems were inflexible and were not compatible with the requirement for local variations. A major problem in extending the industrialised processes within the construction sector is the lack of standardization for systems and products. There are also many possibilities, challenges and barriers in meeting user requirements using a mass-customized approach.</p> <p>Difficulties in an effective application of the prevention from health risks in the working place, specially in the construction sites.</p>				
<b>Technological objectives</b>	<p>To provide conventions and standards for connectivity, so that different industrialised systems may be combined to suit different requirements.</p> <p>To develop more sophisticated monitoring and control systems for construction equipment.</p> <p>To develop and integrate real time diagnostic system for the monitoring of the building (or part of it) under construction and of the materials in arrive at the building site.</p> <p>Feasibility study of the time to market for the developed technologies.</p>				
<b>Approach</b>	<p>Systems for sensing the environment, processing the resulting data, and activating corrective or protective mechanisms will be developed and deployed throughout the whole construction process (the systems could be integrated with European Satellite Positioning System Galileo and using RFID technology).</p> <p>As the price of chip technology falls, every component could in principle be 'intelligent' so as to be part of a component network- based ambient intelligence.</p>				
<b>Results</b>	<p>Industrialised processes in order to meet the needs and expectations of the end users in terms of function, comfort, cost, design and other values by means of efficient planning and production.</p> <p>Complete replacement of human labour in all hazardous conditions.</p> <p>Even on conventional sites, the operation of equipment may be planned and controlled by systems that utilise design data for the building or other structure under construction.</p> <p>Real time monitoring of people and equipments in situ.</p>				
<b>Exploitation</b>	<p>New forms of industrialisation will become as new models for reorganising the construction industry.</p> <p>New methods of risk prevention.</p>				
<b>Impacts</b>	<p>Knowledge-based, client/user demand-driven construction sector.</p> <p>Higher quality and minimized time-to market.</p> <p>Decrease the risk for worker health in construction site.</p>				
<b>Follow-up actions</b>	<p>Creating networking actions for the supporting of the standardization and dissemination.</p> <p>Widely dissemination of the developed know-how &amp; technologies, informing national and European institution, the professional association, the work association.</p>				
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**Utilisation of BIM in knowledge based production planning in construction**

<b>Keywords</b>		Production planning / management, site plan, knowledge management, knowledge based reasoning							
<b>Time to industry</b>		x	Short term			Medium term	X	Long term	
<b>Topic Area</b>		x	2. Industrialised production						
<b>Industrial problem / relevance</b>		In construction, production planning tends to be performed based on personal preferences and experiences. Thus, the industry needs tools and methodologies which enhance the efficiency of routine planning work and enable utilisation of best practices at all construction sites equally. This system would interpret and analyse constructability issues of the design beside the required construction order. It would enable identification of potential problem spots, where further design effort could be directed. Start of the construction phase tends to be very hectic, often due to the client's needs and requirements. This results in multiple tasks performed simultaneously. One of these tasks is production and site planning, which often is fast and superficially, even though this task determines the true efficiency of the construction process, and also affects construction safety and interferences.							
<b>Techno-logical ob-jectives</b>		BIM model checking would be expanded to production issues with new checking rules. The biggest challenge here is to model the tacit knowledge involved with production planning and to develop the analysis methodology for checking compliance or non-compliance.							
<b>Approach</b>		<ol style="list-style-type: none"><li>1. Determination of different view points involved with production planning and management that need to be taken into consideration in the analysis.</li><li>2. Determination of information required in the analysis. Information contains contractual requirements about intermediate goals, schedules, the clients own purchase data, etc.</li><li>3. Methods which enable modelling of knowledge handled in different view points.</li><li>4. Assessment, valuation and prioritisation of different view points. Identification of the planning view points which may be automated. These view points will be prioritised.</li><li>5. Selection of the methodologies and tools that may be utilised.</li><li>6. Gathering of knowledge in order to pilot the methodology and tools.</li><li>7. Constructing the production planning system.</li><li>8. Development of production simulation and visualisation methods.</li><li>9. Pilots + Gathering of the experiences from the pilots. Determining needs for further improvement of the system and methodologies.</li><li>10. Reporting and recommendations. Further research needs.</li></ol>							
<b>Results</b>		<ul style="list-style-type: none"><li>- Knowledge based collaborative production planning system</li><li>- Dynamic production analysis and planning methodology</li><li>- Production simulation and visualisation methods</li><li>- Dynamic/proactive management tools</li><li>- Intelligent site object library (site amenities, protective systems, etc.)</li></ul>							
<b>Exploitation</b>		<ul style="list-style-type: none"><li>- The methodology and the tools will produce: Production schedules, alternative production plans and their simulations &amp; optimum production plans, lists of most important purchases, site plans, plans and requirements for site support operations, etc.</li><li>- Construction site will become a factory. To ensure efficient production, its environment needs to be dynamic with clear routes and schedules for different factors of production.</li><li>- Production intelligence (e.g. site planning, safety rules, constraints etc.) is embedded into a library of site objects off-loading production planners from repetitive calculations with varying methods.</li><li>- Contractors are able to utilise the tacit knowledge and best practices generally utilised only by a few best site planners.</li><li>- The system enables the feedback from the construction site to the designers concerning the design errors (in terms of constructability), design omissions and defective designs increasing the designers' knowledge/capabilities.</li></ul>							
<b>Impacts</b>		<ul style="list-style-type: none"><li>- Management of site becomes dynamic and proactive - the production is more effective.</li><li>- The tool facilitates &amp; speeds up the initial tasks of construction project: becoming acquainted with the project, anticipation of potential problems, preparation of production plans, etc.</li><li>- Despite manpower required to perform routine tasks in production planning is reduced, the quality of production plan &amp; data is improved resulting in reduced risks &amp; errors during production.</li><li>- BIM may also be used more efficiently in the construction process. This requires special user interfaces that provide production the required data in the required form (MVD &amp; IDM).</li></ul>							
<b>Follow-up actions</b>		None							
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## Digital Models

Strategic Action	Objectives
<b>Amending emergency evacuation safety through use of State-of-the-Art ICT applications</b>	Creating a geometry-simplification tool for the BIM- evacuation model information transfer and a tool to import the evacuation simulation results to the BIM. Creating a post-processing tool for the evacuation model application-specific definitions and model consistency checking. Setting up automated library-based knowledge-sharing tools for the description of the human functionality and behaviour in emergency situations such as fire including especially the characteristics of the most vulnerable disabled persons. Carrying out benchmark case analyses to verify the model performance and performing quantified well-instrumented and monitored evacuation drills for the model validation.
<b>Assessment and commissioning approach to improve BEMS and IEQ controllers</b>	<ul style="list-style-type: none"> <li>Realization of a stand-alone software for the simulation of a building and its plant, with a database including a number of models of benchmark buildings and of the main systems typologies, together with a module implementing the main control systems.</li> <li>Feasibility study of an embedded system implementing this software, to be used for the BEMS and IEQ controllers design, commissioning and assessment in laboratory, in the production chain and on site.</li> <li>Definition of service aimed at the optimization of the building-plant complex managing.</li> </ul>
<b>Federated Model Servers</b>	Technologies and standards for distributed modelling, model querying, dependency and constraint propagation and checking. Flexible, fine-grained control of data ownership, access rights and "information contracting". Common semantic meta schema for information and its interaction of existing legacy tools
<b>Innovative Holistic Tools for Building Design &amp; Life-Cycle Management</b>	<p><b>Objective 1 -Lifecycle design and maintenance:</b> To develop a common understanding concerning the core application field of life cycle design, and maintenance &amp; Repair. Also, to do the same with respect to alternative building component selection and design for strategies such as durability, economy and sustainability.</p> <p><b>Objective 2 -Data acquisition, modelling and reasoning:</b> To generate, standardise, harmonise, classify and apply reasoning in order to develop the knowledge model that encapsulate the attributes and rules of the relationship between events that impact upon a building and building components.</p> <p><b>Objective 3 -Simulation, visualisation and model development</b> To design, develop, integrate and validate software components that can practically implement the virtuous cycle of making building maintenance data accessible (in VR and dynamic report) through existing knowledge and generate novel knowledge.</p>
<b>Integration of domain specific models and context based views</b>	<p>Development of an integration platform for the management of building information</p> <ul style="list-style-type: none"> <li>that is able to integrate and merge the different domain specific aspects and partial models.</li> <li>Provision of context specific views (process and role based) to comprehensive data collections</li> <li>Standardised access to model server via web services</li> </ul>
<b>Interoperability of Building Information Models and Fire Safety Engineering Design</b>	The objectives of the project are to develop methods, practises and software to enable seamless interoperability of advanced fire safety design methods and building information model systems, and to demonstrate the results and benefits of the interoperable system through practical design examples applied to management of heat and smoke as well as structural performance in case of fire
<b>InTo Life – Innovative Tools for Life-Cycle Management of our built environment</b>	<p><b>Objective 1 – Development of Structural Condition Assessment Tools:</b> Some of the necessary technologies for a serviceable Life-Cycle Management System are already available and seem to wait for being grasped, adapted to fit its purpose and applied appropriate.</p> <p><b>Objective 2 – Making high-tech Life-Cycle Management Technologies applicable:</b> Although there are different techniques for structural assessment used since several years, the application is still limited to highly specialized or large companies. Reasons are on the one hand side that there are high investments for equipment required and also a herd of experts necessary. On the other hand practicing those techniques needs a lot of expertise. Hence the creation of independent but cooperating life-cycle management techniques based on a common knowledge base and affordable hard- and software is a further objective of the project.</p>
<b>Ontology-based FMECA (Failures Modes Effects and Critically Analysis)</b>	<ul style="list-style-type: none"> <li>A solution to help, simplify, catalyse, and accelerate the use of the FMECA in the Construction sector.</li> <li>Semantic tools to model and formalise the product to be analysed within its context.</li> <li>Creation of structured and reusable repositories of formal descriptions of construction products, materials and hazards.</li> </ul>

Strategic Action	Objectives
<b>Product model based structural design for timber construction</b>	<p>The objectives are to develop a PM based structural design procedure for:</p> <ul style="list-style-type: none"> <li>• timber frame houses (platform frame),</li> <li>• timber element frame,</li> <li>• log houses,</li> <li>• Long span halls,</li> </ul> <p>which is based on Eurocode 5 structural design.</p> <p>These models may also be used as 3d visualisations for customers.</p>
<b>Real Time Visualisation- Beyond Codes</b>	<p>The “real time visualisation -beyond codes” consists of the total system between the 3d plan and the code to communicate.</p>
<b>Risk management applied to construction process - Applications to durability failures in life cycle</b>	<p>The objective of the research is to provide a tool, developed into a software, that will allow to identify construction risks, analyze them and propose which are the best treatments, improving the business strategies.</p> <p>In different ways, this software will help insurance, banks, construction enterprises and designers to estimate in their own fields risks and opportunities, forecasting costs and reducing failure of the projects.</p> <p>Thus far, we can find studies about risk analysis or risk identification techniques and building process frameworks. The new aim is to develop an integrated tool working on all the phases of risk management, useful both in a forecasting and in a diagnostic way.</p>
<b>Semantic Support for Appropriate Digital Presentation</b>	<p>Provide "views" that enable different perspectives on the model.</p>
<b>SIBA (Smart Inventory Building Archives)</b>	<p>We propose to conduct basic research on potential expansion of traditional design tools and evaluate the potential of embedding crucial building information in models / simulations. By using traditional tools, well known and already in use, new additional tools can thus achieve more acceptance among the architects and consultants.</p> <p>The goal of the project is to develop a concept for prototype of “smart inventory data”.</p> <p>Some of traditional design tools already are in fact different kinds of database. The idea is to combine these different kinds of data on one hand and to reduce the amount of data on the other.</p> <p>As new software (“Revit” Autodesk) and new software CAD concepts such as “Building Information Modeling” already offer potential for embedded data to be used during the lifetime of the building, it is essential to define standards for the art and amount of building for embedding.</p>

## Amending emergency evacuation safety through use of State-of-the-Art ICT applications

<b>Keywords</b>	evacuation simulation, building information model, safety, disabled persons, re-engineering				
<b>Time to industry</b>	X	Short term		Medium term	Long term
<b>Topic area</b>	X	3. Digital models	X	5. Interoperability	
<b>Industrial problem / relevance</b>	Using advanced simulation-based evacuation safety assessment tools fire engineers can presently assess whether some design of built-environment will provide possibility for safe evacuation in case of fire. Due to deficient design-modelling communication, however, the evacuation modelling is executed as a separate task that often is not synchronous with the progress of the main design. As provision of sufficient evacuation safety usually sets demands to the architectural and fire safety design, problems arise in the building process causing loss of time and money. In some cases even the safety of the final design solution may be compromised. Seamless ICT-based interoperability between the building design and egress safety design would remove these problems. Through liberating the designers from the model-building, updating and information transfer problems, the interoperable system will enable them to focus on the essential issues of evacuation safety such as the safety of the disabled, which at present is far from being adequately considered.				
<b>Technological objectives</b>	Creating a geometry-simplification tool for the BIM- evacuation model information transfer and a tool to import the evacuation simulation results to the BIM. Creating a post-processing tool for the evacuation model application-specific definitions and model consistency checking. Setting up automated library-based knowledge-sharing tools for the description of the human functionality and behaviour in emergency situations such as fire including especially the characteristics of the most vulnerable disabled persons. Carrying out benchmark case analyses to verify the model performance and performing quantified well-instrumented and monitored evacuation drills for the model validation.				
<b>Approach</b>	The evacuation models to be made interoperable with the BIMs will be the most advanced ones coupling fire simulation and human behaviour modelling. Tools are needed to export information from BIMs and to import the simulation results to BIMs, requiring development of both the evacuation models and BIMs. The end-result will be evacuation safety assessment software with unparalleled ease of use, which calls for high level of verification and validation of the underlying evacuation tools.				
<b>Results</b>	<ol style="list-style-type: none"> <li>1) Geometry-simplification tool for the BIM- evacuation model information transfer and a tool to import the evacuation simulation results to the BIM.</li> <li>2) Post-processing tool for the evacuation model application-specific definitions and model consistency checking.</li> <li>3) Automated library-based knowledge-sharing tools for the description of the human functionality and behaviour in emergency situations such as fire including especially the characteristics of the most vulnerable disabled persons.</li> <li>4) Model V&amp;V.</li> </ol>				
<b>Exploitation</b>	As a result of BIM interoperability, evacuation modelling will become an integral part of building design with seamless interaction between the architectural design and the needs to amend them coming from the evacuation modelling results. The results will be used in practical engineering of buildings and infrastructure to provide safer environment also for the most vulnerable disabled persons.				
<b>Impacts</b>	Through interoperability with evacuation modelling, BIM systems are improved to cover in a comprehensive way one of the most essential requirements of buildings and infrastructure, the safety.				
<b>Follow-up actions</b>	The interoperable BIM-evacuation model systems will be extended beyond the assessment of safety in case of fire to assess accessibility and usability of built environment in general.				
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## Assessment & commissioning approach to improve BEMS & IEQ controllers

<b>Keywords</b>	Benchmark buildings, simulator/emulator, communication protocols.					
<b>Time to industry</b>	X	Short term	X	Medium term		Long term
<b>Topic area</b>	o	3. Digital models	X	6. Collaboration support	o	7. Knowledge sharing
<b>Industrial problem / relevance</b>	<ul style="list-style-type: none"> <li>• Need of simple ways to test the BEMS behaviour when installed in several building typologies with several use patterns, considering in particular lighting control and integration of non-renewable, RES and constructive solutions..</li> <li>• Need to easily communicate with already installed BEMS and controllers for commissioning and assessing</li> <li>• Increase the awareness of the various potentialities of BEMS and their exploitation.</li> </ul>					
<b>Technological objectives</b>	<ul style="list-style-type: none"> <li>• Realization of a stand-alone software for the simulation of a building and its plant, with a database including a number of models of benchmark buildings and of the main systems typologies, together with a module implementing the main control systems.</li> <li>• Feasibility study of an embedded system implementing this software, to be used for the BEMS and IEQ controllers design, commissioning and assessment in laboratory, in the production chain and on site.</li> <li>• Definition of service aimed at the optimization of the building-plant complex managing.</li> </ul>					
<b>Approach</b>	<ul style="list-style-type: none"> <li>• Definition of a set of benchmark buildings according to the different typologies described in the Annex of the EU directive 2002/91/CE.</li> <li>• The aforesaid sets and the models developed by CSTB for its software SIMBAD© will be the starting point towards the design and realization of a stand-alone software for the simulation of a predefined set of buildings and relative equipments.</li> <li>• Feasibility study of an hardware device, in which the foresaid software could be implemented, equipped with the main communication protocols and acquisition/signal generation board in order to be able to interface with real devices.</li> <li>• Definition of a service for the wide use of developed HW and SW.</li> </ul>					
<b>Results</b>	<ul style="list-style-type: none"> <li>• HW device in which a specific SW was implemented connectable to BEMS and IEQ controllers by the main communication protocols</li> <li>• Method for the commissioning optimization also useful as pre-standard work..</li> </ul>					
<b>Exploitation</b>	<ul style="list-style-type: none"> <li>• Energy managers and building managers in general both during the commissioning phase and all along the building operational phase.</li> <li>• Enterprises producing BEMS and IEQ controllers during design phase in order to face their product against several kind of building and use patterns.</li> </ul>					
<b>Impacts</b>	<p>The potential benefit would follow the use of results could be relevant energy savings and IEQ level increasing only optimising the already existing technologies.</p> <p>Also, the availability of specific test rigs would allow to carried out RDI activities on BEMS and IAQ controllers in a more effective way.</p> <p>The results of the activities could be used to realize an hardware system able to emulate a predefined set of benchmark buildings, together with their equipments, to be connected to real controllers or other physical devices: this system could be used directly in the production/test chain of potential producers of control devices.</p> <p>Once realized, the hardware device could be improved in order to be integrated in a wider system aiming at emulating loads (for example using heater exchanger) and production systems (boiler, refrigerators, both real and simulated).</p>					
<b>Follow-up actions</b>	<ul style="list-style-type: none"> <li>• Based on a preliminary mock-up developed in some R&amp;D project, experimentation within small groups, then generalisation of the approach.</li> <li>• Carried on of specific case studies both in the farm production chain and in the real buildings through the necessary collaboration with enterprises and building managers.</li> </ul>					
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## Federated Model Servers

Keywords		Distributed PMs, interoperability, IPR, distributete				
Time to industry	x	Short term	x	Medium term		Long term
Topic area	x	3. Digital models			x	6. Collaboration support
	x	5. Interoperability			x	8. ICT enabled business models
Industrial problem / relevance		Hesitation to upload all information to centralized model servers. Necessity to run internal DBs of specialised domain tools. Interest to keep general company knowledge separated from project-specific knowledge. Cultural and Legal issues, make a gradual shift (instead on pushin everything onto a centralized server)				
Technological objectives		Technologies and standards for distributed modelling, model querying, dependency and constraint propagation and checking. Flexible, fine-grained control of data ownership, access rights and “information contracting”. Common semantic meta schema for information and its interaction of existing legacy tools				
Approach		Extend federated database technology to specific needs of information and processes in B&C industry. Develop and improve existing DBMSs. Create a common, open meta-DB-schema for mappings by end-user-developers of commercial products.				
Results		Web-based servers, CAD servers, design tool servers, federated model server management tools, common meta-query languages for federation,				
Exploitation		New companies from spin-offs provide connection points with a federated meta schema and query starting point. Developers of existing legacy domain systems map their internal representation to it and provide query interfaces. In new construction projects instances of tools used by project participants are connected together on project plaforms				
Impacts		Permanent interoperability, ambient interoperability, just in time tool federation				
Follow-up actions		None				
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## Innovative Holistic Tools for Building Design & Life-Cycle Management

<b>Keywords</b> Life-Cycle Management, Maintenance Scheduling, Knowledge-based Decision Support				
<b>Time to industry</b>	x	Short term	Medium term	Long term
<b>Topic area</b>	X	<b>3. Digital Models</b>		
<b>Industrial problem / relevance</b>	Stakeholders associated with construction sector have increasingly recognised the importance and need for an integrated and holistic toll for building and infrastructure design and maintenance. Construction sector is driven by total product life performance and supported by knowledge-intensive and model based ICT enabling holistic support and decision making throughout the various business processes and the whole product life cycle by all stakeholders. Various stakeholders within the sector require rational decision and effective decision tolls for both design and maintenance and repair scheduling. Due attention to design for life cycle consideration will have significant social, economical and environmental implications.			
<b>Techno-logical objectives</b>	<b>Objective 1 -Lifecycle design and maintenance:</b> To develop a common understanding concerning the core application field of life cycle design, and maintenance & Repair. Also, to do the same with respect to alternative building component selection and design for strategies such as durability, economy and sustainability. <b>Objective 2 -Data acquisition, modelling and reasoning:</b> To generate, standardise, harmonise, classify and apply reasoning in order to develop the knowledge model that encapsulate the attributes and rules of the relationship between events that impact upon a building and building components. <b>Objective 3 -Simulation, visualisation and model development</b> To design, develop, integrate and validate software components that can practically implement the virtuous cycle of making building maintenance data accessible (in VR and dynamic report) through existing knowledge and generate novel knowledge.			
<b>Approach</b>	Ideally, this is an IP but also STREP could be exploited. <b>STREP:</b> Develop a model-driven, data rich construction component design system that is powered by visualisation techniques. Facilitate data collection through a web-based brokerage system. While the modelling phase should take advantage of multi-agent approach, the decision making should benefit from the use of visualisation techniques. <b>IP:</b> Same as STREP with a workable prototype, extensive initial data collection, processing, analysis and system population.			
<b>Results</b>	A real-time holistic decision support tool for designing and selection of building and/or infrastructure components with real-time indication of life cycle implication, taking into account a range of decision criteria contained associated with social, environmental, and economical considerations. These include whole life cycle costing, energy consumptions, aesthetic qualities, recycling, waste control, personal, social and communal impacts, etc.			
<b>Exploitation</b>	The tools could be exploited at different levels by a range of stakeholders: individuals involved in the development could use the tools within their respective organisations or they could be commercialised once IPR principals are determined and business models are agreed. Potential beneficiaries include clients, designers, constructors, end-users, engineers, quantity and building surveyors, lenders, national and local authorities and other interest and pressure groups. Within research community the dissemination plans include publication of results in conferences, exhibitions, trade & refereed learned journals, web-site, public electronic newsletter, university course curriculum, visiting lectures, lecture notes, briefing notes to international technical committees, press release, seminars and workshops, and federalisation through mobility of the army of researchers involved in the project.			
<b>Impacts</b>	The tools will help to overcome a hitherto problematic European issue relating to the incorporation of lifecycle considerations into building design and maintenance processes as well as large-scale contribution to environmental protection campaign. The social, economical and environmental impact of the resulting tools is significant at all levels ranging from individual to local, national levels and for Europe's competitiveness. The design of the life-cycle management systems comprises the improvement of available tools for performance monitoring (sophisticated measurement equipment, high quality data acquisition systems, methods for data evaluation and system identification) but also requires the development of new instruments such as knowledge based decision support, algorithms for data processing and automated model update.			
<b>Follow-up actions</b>	To energeise the latent industrial support for this tool into more coherent move towards a more coordinated action towards provision of specific objectives as well as mobilising relevant stakeholders for their implementation.			
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## Integration of domain specific models and context based views

<b>Keywords</b>	Model server, product data management, digital models, model matching					
<b>Time to industry</b>		Short term	x	Medium term		Long term
<b>Topic area</b>	x	3. Digital models	x	5. Interoperability	x	6. Collaboration support
<b>Industrial problem / relevance</b>	<p>The different actors in the lifecycle of buildings have specific demands for information that arise from their respective context in the process. Especially the participants of later phases like building contractors or facility managers need a holistic description of the building that is aggregated out of heterogeneous sources and that is result of various processes.</p> <p>But in practice the flow of information is mostly a sequential transfer of partial information and single aspects. So – also based of inadequate interfaces - important data is often lost in the chain of information.</p> <p>Furthermore the different participants of the design, construction and management process have different methods for the description and mapping of buildings and their domain specific aspects. Also if the information is accessible in general, the different domain aspects does'nt fit together.</p>					
<b>Technological objectives</b>	<p>Development of an integration platform for the management of building information</p> <ul style="list-style-type: none"> <li>• that is able to integrate and merge the different domain specific aspects and partial models.</li> <li>• Provision of context specific views (process and role based) to comprehensive data collections</li> <li>• Standardised access to model server via web services</li> </ul>					
<b>Approach</b>	<ul style="list-style-type: none"> <li>• Standardised specification of product and process</li> <li>• Centralised model management</li> <li>• Methods for the mapping and merging of partial models and domain specific aspects</li> <li>• Methods for change management to assure the consistence of the data</li> <li>• Densification and refinement of information</li> <li>• Support of distributed information access for the different processural and organisational contexts in a collaborative environment</li> </ul>					
<b>Results</b>	<ul style="list-style-type: none"> <li>• Integrated standardised building information model</li> <li>• Model management system</li> <li>• Domain superordinated ontology for building description</li> <li>• Platform for the distributed access of model data</li> <li>• Provision of adequate building data for connected thirty party products</li> </ul>					
<b>Exploitation</b>	<ul style="list-style-type: none"> <li>• Flexible queries accomplish the specific demand of information for all the participants and process-applications in an efficient way</li> <li>• Consistent flow of information and neutral shared information base for the user of connected applications</li> <li>• Implementation of data standards facilitates the integration of thirty party products.</li> </ul>					
<b>Impacts</b>	<p>An integrated information base is an important precondition to achieve an added value throughout the lifecycle of buildings. Based on such a holistic description of an building, the generation of comprehensive views can be realised, that fit to the process specific need of different contexts and to facilitate a seamless chain of information.</p>					
<b>Follow-up actions</b>	<ul style="list-style-type: none"> <li>• Upgrading of data standards like IFC to handle the different domain aspects and to accomplish the requirements of different lifecycle phases</li> <li>• Integration of product data management systems and collaboration platforms (company portal or project platform)</li> </ul>					
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## Interoperability of Building Information Models and Fire Safety Engineering Design

<b>Keywords</b>	fire simulation, structural analysis, building information model, safety, re-engineering				
<b>Time to industry</b>	X	Short term		Medium term	Long term
<b>Topic area</b>	X	3. Digital models	X	5. Interoperability	
<b>Industrial problem / relevance</b>	<p>Even today structural fire design is based on the more-than-a-century-old strongly schematised standard fire conditions and analysis of single components, rather than the whole structure, which for modern buildings is an overly conservative approach.</p> <p>Due to advances in the fire sciences and computer technology, it is possible to supersede this outdated method and use a rational fire safety engineering (FSE) approach that comprises simulation of the real fire exposure and advanced thermo-mechanical analysis of the structural response. Structural FSE (SFSE) enables better integration of fire safety design and the needs of multifunctional building performance and, hence, allows for novel, more flexible building designs and acts as a stimulant for innovative solutions and materials.</p> <p>Yet, at present, as the SFSE tools do not interoperate with the building design tools, their use necessitates tedious reconstructing of the building geometry and other relevant information. This makes the use of the SFSE inefficient and rather costly thus hampering their application in the hectic and modern building process aiming at optimised cost-effectiveness.</p> <p>As a result BIM-SFSE interoperability, use of SFSE will be turned into a practical cost-effective engineering tool for the design of buildings and infrastructure. When the extensive collection of data included in BIMs are made available in fire and structural design to it will speed up the design process and to improve its quality.</p>				
<b>Techno-logical objectives</b>	The objectives of the project are to develop methods, practises and software to enable seamless interoperability of advanced fire safety design methods and building information model systems, and to demonstrate the results and benefits of the interoperable system through practical design examples applied to management of heat and smoke as well as structural performance in case of fire				
<b>Approach</b>	<p><u>General modules:</u> 1) Development of a geometry-simplification tool to extract from the building information model the input information relevant to the fire and structural models as well as creating an automated post-processing tool the needed for the application-specific definitions and model consistency checking. 2) Tool to import the fire and structural simulation results to the BIM. <u>Fire simulation module:</u> generation of automated library-based knowledge-sharing tools for the description of the design fires and fire safety measures <u>Heat-exposure module:</u> coupling a fire model predicting the thermal conditions and the structural analysis model through a heat-transfer-model <u>Mechanical response module:</u> a mechanical response model predicting the structural performance under the given thermal exposure</p>				
<b>Results</b>	1) Geometry-simplification tool for the BIM- fire/structural model information transfer. 2) Automated post-processing tool for the application-specific definitions and model consistency checking. 3) Tool to import the fire and structural simulation results to the BIM. 4) Automated library-based knowledge-sharing tools for the description of the fire-related specifications. 5) Heat-exposure tool coupling the fire model and the structural analysis model. 6) Mechanical response tool predicting the structural performance under the given thermal exposure				
<b>Exploitation</b>	As a result of BIM interoperability, advanced fire design and structural analysis software will become tools for their end-users in practical engineering of buildings and infrastructure on an entirely new level of cost-effectiveness. The results will be distributed mainly as freeware similarly to the core fire-analysis tools used.				
<b>Impacts</b>	Through interoperability with the advanced fire safety and structural design methods, BIM systems are improved to cover more aspects of the essential requirements of construction than before. The project thus enhances the quality and productivity of the overall design process of buildings and infrastructure.				
<b>Follow-up actions</b>	Further development to attain fully flexible interoperability without any distinct boundaries between the different modules and the whole BIM system				
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## InTo Life – Innovative Tools for Life-Cycle Management of our built environment

<b>Keywords</b>	Life-Cycle Management, Condition Assessment, Knowledgebased Decision Support, Smart Structures					
<b>Time to industry</b>	x	Short term		Medium term		Long term
<b>Topic area</b>	o	3. Digital models	x	4. Intelligent constructions	o	7. Knowledge sharing
<b>Industrial problem / relevance</b>	<p>The European infrastructure network is characterized by a huge number of ageing civil infrastructure systems such as bridges, viaducts, tunnels and dams. The performance of many of these in-service structures has decayed and the inherent level of safety can be shown to be inadequate relative to current design documents.</p> <p>After years of maintenance-free operation, owners and competent authorities require rational decision criteria and methods to assign the budgets for maintenance and repair. The budget became very tight the last years not only due to an absolute increase of rehabilitation expenses but also because of reduced funds.</p> <p>Economists and Engineers see an overarching Life-Cycle Management System as the forward-looking solution for the identified gaps between very long-term infrastructures and current short-term approach to design, management and maintenance planning.</p> <p>Currently the repair is reactive, why the need of repair is recognised at a very advanced stage of deterioration. A well timed and focused rehabilitation measure does not only reduce costs for the current measure but also has a significant impact on the life-cycle performance of a structure.</p>					
<b>Technological objectives</b>	<p><b>Objective 1 – Development of Structural Condition Assessment Tools:</b> Some of the necessary technologies for a serviceable Life-Cycle Management System are already available and seem to wait for being grasped, adapted to fit its purpose and applied appropriate.</p> <p><b>Objective 2 – Making high-tech Life-Cycle Management Technologies applicable:</b> Although there are different techniques for structural assessment used since several years, the application is still limited to highly specialized or large companies. Reasons are on the one hand side that there are high investments for equipment required and also a herd of experts necessary. On the other hand practicing those techniques needs a lot of expertise. Hence the creation of independent but cooperating life-cycle management techniques based on a common knowledge base and affordable hard- and software is a further objective of the project.</p>					
<b>Approach</b>	<p>A research initiative dedicated to Innovative Life-Cycle Tools</p> <ul style="list-style-type: none"> <li>• State-of-the-art in SHM and Life-Cycle Management</li> <li>• Identification of technologies to be considered</li> <li>• Conception of the integration</li> </ul> <ul style="list-style-type: none"> <li>• Data harmonisation – standards and interfaces</li> <li>Creation of a knowledge database</li> <li>• Decision support systems</li> <li>• Automated model update, Simulation</li> </ul> <p>Strep or Specific Actions supporting SME would be proper instruments for RTD work.</p>					
<b>Results</b>	Decision Support System for Online Monitoring Installations based on Pattern Recognition; Automated FE-model Update from measurement data for System Identification, Damage Detection and Risk Assessment.					
<b>Exploitation</b>	Within the project the expertises of condition assessment of the civil and mechanical engineers have to be joined with the potential offered by ICT. The capability of applied knowledge processing based enables a whole system for Life-Cycle Management. In essence companies with capacities for application are developing tools supported by universities based on available technologies. These companies can rely on their long lasting business connections between engineering consultants and enduser which are the essential key for applied Life-Cycle Management.					
<b>Impacts</b>	<p>The impact of the resulting tools from the project is very high both for the competitiveness of European SMEs and for contribution to solving a problem in the management and financing of ageing infrastructures in all countries of the European Union.</p> <p>With the development of intelligent software tools which complement each other to an overall instrument for life-cycle management gives also small and specialized companies the possibility to benefit from the demand in life-cycle management consulting services. Furthermore the application of life-cycle management optimises the human conditions such as safety, health and comfort.</p> <p>The design of the life-cycle management Systems comprises the improvement of available tools for structural health monitoring (sophisticated measurement equipment, high quality data acquisition systems, methods for data evaluation and system identification) but also requires the development of new instruments such as knowledge based decision support, algorithms for data processing and automated model update.</p>					
<b>Follow-up actions</b>	The conservative and critical attitude to new methods in civil engineering will need a lot of effort to exploit the project output.					
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**Ontology-based FMECA (Failures Modes Effects and Critically Analysis)**

<b>Keywords</b>		FMECA, Ontology, product models													
<b>Time to industry</b>		X		Short term				Medium term				Long term			
<b>Topic area</b>	X	1. Value-driven business processes						o	2. Industrialised production				o	5. Interoperability	
	X	6. Collaboration support						X	7. Knowledge sharing						
<b>Industrial problem / relevance</b>		FMECA is an efficient and well defined method to prevent hazards on processes or products. Applied to the analysis of potential degradation of construction products, this method presents two disadvantages: (i) it requires good knowledge (i.e., only experts can use it) on the products concerned; and (ii) is a time consuming process.													
<b>Technological objectives</b>		<ul style="list-style-type: none"><li>• A solution to help, simplify, catalyse, and accelerate the use of the FMECA in the Construction sector.</li><li>• Semantic tools to model and formalise the product to be analysed within its context.</li><li>• Creation of structured and reusable repositories of formal descriptions of construction products, materials and hazards.</li></ul>													
<b>Approach</b>		In collaboration with FMECA specialists, samples of construction products are to be created. These examples will be formally modelled (components, geometric structure, materials used, potential degradations that may occur, mechanisms, processes and agents that can lead to degradation). This formal description will be stored in an extensible ontology. Additionally, the process followed to produce this ontology will be formalised and proposed as a methodological approach which is going to be delivered as part of the results.													
<b>Results</b>		<ul style="list-style-type: none"><li>• A software solution based on inference rules and an ontology to help performing “automatically” or semi automatically with hazard analysis;</li><li>• Bootstrapping ontologies (easily extensible) for different products;</li><li>• Methodology / recommendation to extend or write down new ontologies to analyse new products</li></ul>													
<b>Exploitation</b>		<ul style="list-style-type: none"><li>• This software could be used by organisations already doing such FMECA analysis.</li><li>• Product companies may have interest in this solution in order to test the digital mock-up of new products.</li></ul>													
<b>Impacts</b>		<ul style="list-style-type: none"><li>• Enhance the quality / durability of product;</li><li>• Prevent design errors;</li><li>• Capitalise on specialised knowledge;</li></ul>													
<b>Follow-up actions</b>		Select key organisations already using the FMECA and show the potential business benefits they can have by adopting this solution.													
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**Product model based structural design for timber construction**

Keywords	Timber, wood, construction, design				
Time to industry	X	Short term	X	Medium term	Long term
Topic area	X	2. Industrialised production			
Industrial problem / relevance	<p>Product model based design has (to my information) not been applied on timber construction (as it has been for steel and concrete).</p> <p>Timber design is often complicated and structural designers need tools for timber structural design. The new Eurocodes make the structural design of structures more complicated and at present there is limited know-how on these among the designers. The Eurocodes have to be taken to use by 2010.</p>				
Technological objectives	<p>The objectives are to develop a PM based structural design procedure for:</p> <ul style="list-style-type: none"><li>• timber frame houses (platform frame),</li><li>• timber element frame,</li><li>• log houses,</li><li>• Long span halls,</li></ul> <p>which is based on Eurocode 5 structural design.</p> <p>These models may also be used as 3d visualisations for customers.</p>				
Approach	<p>The wood structure group in VTT have in-depth knowledge on Eurocode design and on CEN standards. Further building physical, acoustic and environmental expertise may as well be embedded.</p>				
Results	<p>Automated tools for the design of timber houses are developed.</p> <p>Intelligent catalogues of the building parts to be produced.</p> <p>Building process logistics and fast assembly optimised for efficient building and minimal weather protection.</p> <p>A building parts catalogue for every building (as for cars).</p>				
Exploitation	<p>The work should be done in cooperation with the respective timber industry.</p>				
Impacts	<p>The ease of design will enhance the use of wood in construction and design errors shall be avoided.</p> <p>New business opportunities for SME wood working industries</p>				
Follow-up actions	None				
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## Real Time Visualisation- Beyond Codes

<b>Keywords</b>	Visualisation, Model, codes, User media, Downloadable				
<b>Time to industry</b>		Short term	X	Medium term	Long term
<b>Topic area</b>	x	3. Digital models	o	7. Knowledge sharing	o 8. ICT enabled business models
<b>Industrial problem / relevance</b>	There is now widely emerging use of real 3D files. The situation will rise practical problems /Challenges which could be new business potential. For instance the “real time visualisation of codes” could benefit not only the customer but also the designer.				
<b>Technological objectives</b>	The “real time visualisation -beyond codes” consists of the total system between the 3d plan and the code to communicate.				
<b>Approach</b>	Develop the total logig to support the designer , user etc. to see real time the effects of different codes to the plan during design process. The different codes (building code, fire rules etc) could be checked technically (“solibri model checker like”) and at the same time the possible chances are constantly validated visually. The code information comes from server wich is also updating the codes automatically (“ f-secure like-analogy to updating virus information”) . This approach makes place to new player (business model) to make “cV-secure” service with state-of-the-art web- services etc. (c stands for code, V for Visualisation !).				
<b>Results</b>	<ul style="list-style-type: none"> <li>• End user and designer tools to see &amp; communicat visually the results of codes to various decisions</li> <li>• =&gt; decision support tool, scenario tool</li> </ul>				
<b>Exploitation</b>	<ul style="list-style-type: none"> <li>• The new business around the “cV-checker”</li> <li>• ...supported by server automatically updating “cV definitions”...</li> <li>• ...application independent !</li> <li>• EU-wide network (Branding ..) ?</li> <li>• =&gt; The designers / Users /decision makers can freely communicate &amp; compare different technologies and designs having live impact of codes , rules etc..</li> <li>• Manufacturers can also start multi-optimize their product to certain codes, rules combinations easily...</li> <li>• =&gt; value for customer !</li> </ul>				
<b>Impacts</b>	<ul style="list-style-type: none"> <li>• European wide market</li> <li>• Knowledge based communication &amp; decision tool for construction sector</li> <li>• New business opportunities to specialized web/server/ ? companies</li> </ul>				
<b>Follow-up actions</b>	Standardisation and horisontal information flowis speeding and updated more flexible because of activated communiaction. The possibility for new business model.				
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## Risk management applied to construction process -Applications to durability failures in life cycle

<b>Keywords</b>	Risk identification, Risk analysis, Durability, Construction process, Life cycle						
<b>Time to industry</b>		Short term		x	Medium term		Long term
<b>Topic area</b>	x	1. Value-driven business processes			x	8. ICT enabled business models	
<b>Industrial problem / relevance</b>	<p>The 2004 Basil agreement (among banks) and the new national laws (about building long-term insurances) have created a new context for building global market in which costs are growing up over and over, falling upon the construction companies or the final users.</p> <p>Banks, Insurance companies, Building enterprises and Designers (Architects and Engineers) need tools to manage better the uncertainties of the construction projects.</p> <p>There is a lack of knowledge about the estimation of risk during the life cycle of buildings, because of the complex scenarios of construction process. These scenarios are very difficult to be modelled, particularly when relative to the relationship among decisions made in the first steps of the project and their consequences in the last phases. If risks are not managed they become unexpected costs.</p>						
<b>Techno-logical objectives</b>	<p>The objective of the research is to provide a tool, developed into a software, that will allow to identify construction risks, analyze them and propose which are the best treatments, improving the business strategies. In different ways, this software will help insurance, banks, construction enterprises and designers to estimate in their own fields risks and opportunities, forecasting costs and reducing failure of the projects. Thus far, we can find studies about risk analysis or risk identification techniques and building process frameworks. The new aim is to develop an integrated tool working on all the phases of risk management, useful both in a forecasting and in a diagnostic way.</p>						
<b>Approach</b>	<p>The research approach will start developing a very detailed building process framework that will be the baseline on which organize risk management phases. As far as concerns risk identification, analysis, treatment and monitoring, there will be used different tools (FMECA, AHP techniques, and several gravity assessment techniques) that will be combined into a unique software tools able to work through every building process phase, supporting the decisions making of the different actors, thanks also to the use of Bayesian Networks which manage the scenarios coming out from the combination of FMECA failure modes. Their application is thought to be feasible thanks to the possibility to implement mathematical models and expert knowledge.</p> <p>A particular application will be developed as a case study, with attention to durability failures in life cycle.</p> <p>The necessary competencies will be provided by software companies, insurance companies, banks (or financing institutes) and construction enterprises.</p>						
<b>Results</b>	<p>The result of the research will be a risk management software used for different purposes by the different users (e.g.: banks for financing risks, insurance companies for durability failures, construction enterprises for cost and time risks).</p> <p>The software will be based on analytic method of risk identification and risk analysis (FMECA, AHP, Bayesian networks) and will provide support both as a decision making and a diagnostic tools for all the building process phases. It will so be possible forecast how a decision taken in a particular moment of the project will influence the next stages, and in other way what to do to achieve a particular expected result, exploiting the Bayesian Network's feature relative to propagation of conditional probabilities.</p> <p>The particular application on durability will represent one tangible result useful for insurance companies or designers.</p>						
<b>Exploitation</b>	<p>Construction, Insurance companies, Designers (or Engineering studios) could use the software to simulate complex scenarios and work using a common language on construction risks.</p> <p>If different actors involved in the same project were able to share the starting data it would be possible to optimize the business strategies, reducing costs and improving the overall quality.</p>						
<b>Impacts</b>	<p>There are different potential benefits coming out by application of risk management to construction business and process. Reducing and monitoring risks means, first of all, saving money and improving quality of the project (both time consuming and technological). So it could be more simple to access to project financing and reduce the insurance cost during the life cycle (both for construction enterprises and final users).</p> <p>In a medium/long term view also the public costumers could be interested because of the frequent needs of the government project to obtain private financing. In this way the tool here proposed will provide the opportunity to study risk and business strategies that could represent the right approach to involve private partners interested to manage the final activity.</p>						
<b>Follow-up actions</b>	<p>In a long term view, to develop a common approach to risk and to work using sensible data, it will be very important to build a data base, in which the different experiences will be catalogued and organized. That could provide useful information about probability and consequences of construction risks.</p>						
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## Semantic Support for Appropriate Digital Presentation

Keywords		Semantic; digital; presentation; BIM; ontologies			
Time to industry	x	Short term		Medium term	Long term
Topic area	x	3. Digital models			
Industrial problem / relevance	Need to filter irrelevant information to check for inconsistency. Present so that user can understand				
Technological objectives	Provide "views" that enable different perspectives on the model.				
Approach	Standard language. Join IFC and other relevant open standards (GML, transXML, IFD, etc.)				
Results	Tools, standards --> real-time model viewing using task based sensing, mobile devices, ambient access.				
Exploitation	Open source solutions, risk clients				
Impacts	Saving lives, saving time, saving money				
Follow-up actions	Close cooperation with clients and users; make aware of potential of 3D Models				
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**SIBA (Smart Inventory Building Archives)**

<b>Keywords</b>	Building Database, 3dmodelling tools, Life Cycle Analysis, Sustainable building materials, Industry Foundation Classes							
<b>Time to industry</b>	X	Short term	X	Medium term		Long term		
<b>Topic area</b>	X	1. Value-driven business processes	X	3. Digital models	X	5. Interoperability		
<b>Industrial problem / relevance</b>	<p>For future operation and refurbishment of new buildings as well as existing building stock reliable design information as well as simple, easy to use archives in form of complex simulation containing data on building parts, building performance, services, architectural aesthetics and information needed for life cycle analysis are necessary. The enormous amount of various data accumulated during the design and completion phase of buildings needs to be reduced to a manageable und necessary quantity. Our idea is to generate a small yet smart inventory of building parts and techniques as a by-product of traditional design tools and assess the potential of embedding this data within the simulation of the building.</p> <p>Possible information gathered in the “by-product building data inventory” can be data on energy and building physics, bearing strength, chemical composition etc., but also relevant information on the artistic /architectural /aesthetic aspects of the design, such as color schemes and material surfaces but also concepts of use.</p>							
<b>Technological objectives</b>	<p>We propose to conduct basic research on potential expansion of traditional design tools and evaluate the potential of embedding crucial building information in models / simulations. By using traditional tools, well known and already in use, new additional tools can thus achieve more acceptance among the architects and consultants.</p> <p>The goal of the project is to develop a concept for prototype of “smart inventory data”.</p> <p>Some of traditional design tools already are in fact different kinds of database. The idea is to combine these different kinds of data on one hand and to reduce the amount of data on the other.</p> <p>As new software (“Revit” Autodesk) and new software CAD concepts such as “Building Information Modeling” already offer potential for embedded data to be used during the lifetime of the building, it is essential to define standards for the art and amount of building for embedding.</p>							
<b>Approach</b>	<p><u>Methodical approach:</u> Proposed examination / evaluation:</p> <ul style="list-style-type: none"> <li>• Stage I: Evaluation and assessment of Traditional Planning Tools</li> <li>• Stage II: Research on building data</li> <li>• Stage III: Minimizing the data / Setting standards</li> <li>• Stage IV: Case Study: “Smart Data” standard applied to sustainable materials und techniques</li> <li>• Stage V: Concept for a product prototypes</li> </ul>							
<b>Results</b>	<ol style="list-style-type: none"> <li>1. Guideline “Smart Inventory for Future Assembling” (suitable database structure, recommendations on amount and kind of building information)</li> <li>2. Building Industry / Manufacturers Guideline for technical information and data on building products, materials and techniques</li> <li>3. Measures to achieve element oriented design and assembly based production</li> <li>4. Case Study based upon sustainable building materials</li> <li>5. Concepts for product prototypes (Software products)</li> </ol>							
<b>Exploitation</b>	<p>Guidelines for manufacturers</p> <p>Manual with concepts for product prototypes for software firms</p> <p>Case study “Sustainable building materials”</p>							
<b>Impacts</b>	<p>„Smart Inventory Data“ is a new kind of a virtual document that includes all relevant information about a specific building for future management und refurbishment. During the construction phase as well as during the life span of the building the database can be updated.</p> <p>List of potential users: building owners, facility managers, planners (refurbishment / reconstruction) dwellers, authorities...</p>							
<b>Follow-up actions</b>	<p>Development of product prototypes (implementing concepts for product prototypes)</p> <p>Dissemination of “Guidelines for Manufacturers”</p>							
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## Intelligent Constructions

Strategic Action	Objectives
<b>Active energy intelligent buildings</b>	<ul style="list-style-type: none"> <li>• Predictive building control methodology, especially based on standardized, integrated building information models</li> <li>• Key Performance Indicators (see EPBD) and decision-systems for energy efficiency in the Construction sector</li> <li>• Combination of energy simulation and “real-time” sensor data analysis</li> <li>• ICT support for global/local strategies in distributed energy systems, and for global integrated (systemic) approach in the building to maximise energy efficiency, to reduce environmental impact (material use, waste, water,...) and to optimise the indoor climate conditions</li> <li>• integration or extension of available intelligent house appliance systems</li> <li>• Using grid-based data management approach</li> <li>• Developing load-balancing data management algorithms</li> </ul>
<b>Building Memory</b>	<p>This project investigates the feasibility of Building Memory system, which tracks and relates dynamic data collected by sensors distributed in facilities. Compared with existing solutions (such as energy management and control systems), the proposed Building Memory system would provide improved support to monitor, process, organize, and query sensor data. Technologies used to develop such a system include data-driven/inverse, information-rich building models, distributed datastream management systems, spatio-temporal databases, and data mining/trend analysis.</p>
<b>Digital Home platform and services</b>	<p>The project will develop new LC service concepts and models as well, enabling business models for the future digital housing and proof the concept via demonstrations and experiments. New modular product concepts, also to be developed, will be focused on intelligent space and technical systems solutions. LC management and services will be enabled by the digital home platform and building information model adapted and extended to residential applications.</p>
<b>Early warning system for strategic buildings and infrastructures</b>	<p>Development of analysis and simulation tools for the early warning alert and the structural protection activation within the 20 seconds advance given by a reliable transmission system on the propagation time of seismic waves on a 100 km distance.</p>
<b>Embedded sensors for the self environmental monitoring network in construction</b>	<p>The objective is to transfer in the construction field the concept of real-time global monitoring network which could reduce the emissions and increase the energy efficiency. This system should consist of low cost distributed sensors. This system can correct malpractice of the people who live in the buildings which are a great source with a huge weight in the environmental impact.</p>
<b>Energy Saving through intelligent heating management</b>	<p>Develop dedicated optical fiber cables and packaging for distributed remote sensing in structures and building (temperature).</p> <p>Test the possibility to use telecom fibers for data transmission and for temperature sensing in the same time. In that case, optical fiber cables installed in building should be used as distributed sensors, reducing the investment costs for sensing.</p> <p>Validate global concept of heating control based on distributed temperature sensing with end users. Cost benefit and cost recovery analysis.</p>
<b>Monitoring of wooden structures</b>	<p>The objective is to develop monitoring techniques and practices for remote diagnostics and serviceability control of wooden structures.</p> <ul style="list-style-type: none"> <li>• Detection of excess humidity in air and in wood</li> <li>• Detection of excess deformations in known critical parts</li> <li>• Cracks of structures in known critical parts</li> <li>• Adding information on settings on servicing and maintenance schedules, etc.</li> </ul>
<b>Self-adapting built environments</b>	<p>The main objective is developing an advanced and intelligent control system that was able of self-adapting the HVAC system taking into account the users preferences and the context.</p>
<b>Structure Monitoring based on embedded distributed sensors</b>	<p>Develop dedicated <i>optical fiber cables and packaging</i> devoted to distributed remote sensing in CE structures (strain, displacement, temperature, corrosion, bending,...).</p> <p>Validate global concept of remote distributed sensing with end users. Cost benefit analysis.</p>
<b>Traffic Control, roads and high-ways safety with optical fibers</b>	<p>Develop dedicated sensors to be embedded in sub surface of road cover, based on optical fiber technology. Develop dedicated software for sensors monitoring, including man-machine interface for remote control</p>

Strategic Action	Objectives
<b>Europe goes Zero – Advanced European EE Buildings</b>	<ul style="list-style-type: none"> <li>• Double the energy efficiency in the building stock in 2020</li> <li>• Towards zero energy consumption in buildings</li> <li>• Increase the awareness and motivation for energy saving measures of the public, the communities and the industry</li> <li>• Enforce energy performance requirements for new and existing buildings</li> <li>• Realise demonstration projects for high efficient and zero energy buildings all over Europe</li> </ul>
<b>LowEx Communities - Towards a more sustainable society</b>	<p>The main objective of the proposed action is the concept development and demonstration of exergy distribution, generation and storage systems that meet all exergy demands of community members with a minimum input of primary energy.</p> <p>Exergy is a concept which helps us distinguish between two parts of an energy flow: exergy and anergy. Only the exergy part of any energy flow can be converted into some kind of high-grade energy such as mechanical work or electricity. Anergy, on the other hand, refers to the part of the energy flow which cannot be converted into high-grade energy (e.g. low-grade waste heat from a power plant). Exergy can be regarded as the valuable part of energy, while anergy designates the low-value portion. The Low Exergy (LowEx) approach entails matching the quality levels of exergy supply and demand, in order to streamline the utilisation of high-value energy resources and minimise the irreversible dissipation of low-value energy into the environment.</p>



## Active energy intelligent buildings

Keywords	ICT supporting Clean Buildings, Wireless Sensors, nDimensional Information Management				
Time to industry		Short term	x	Medium term	Long term
Topic area	X	4. Intelligent constructions			
Industrial problem/ relevance	<p>The EU Energy Performance Buildings Directive (EPBD) came into law in January 2003. Member states had to implement it into national law 2006. EPBD places an onus on building owners to rate the energy performance of their buildings. Most components to support the energy efficient operation of buildings are neither integrated with each other nor is their performance continuously monitored or analysed. The installation of wired sensors is expensive (90% of costs for wiring). Building control systems are rather re-active than pro-active. Overall, there is:</p> <ul style="list-style-type: none"><li>• Lack of methodology for impact assessment – defining the indicators, providing/getting accurate energy information, etc.;</li><li>• Lack of information to consumers to control &amp; manage energy consumption/demand;</li><li>• lack of “intelligence” in energy management systems – for controlling / optimising energy &amp; interacting with users;</li><li>• Lack of competitive and low cost wireless distributed sensor systems;</li><li>• Lack of smart building technology showcases / demonstrators.</li></ul>				
Techno- logical ob- jectives	<ul style="list-style-type: none"><li>• Predictive building control methodology, especially based on standardized, integrated building information models</li><li>• Key Performance Indicators (see EPBD) and decision-systems for energy efficiency in the Construction sector</li><li>• Combination of energy simulation and “real-time” sensor data analysis</li><li>• ICT support for global/local strategies in distributed energy systems, and for global integrated (systemic) approach in the building to maximise energy efficiency, to reduce environmental impact (material use, waste, water,...) and to optimise the indoor climate conditions</li><li>• integration or extension of available intelligent house appliance systems</li><li>• Using grid-based data management approach</li><li>• Developing load-balancing data management algorithms</li></ul>				
Approach	<ul style="list-style-type: none"><li>• State-of-the-art analysis of building control systems, architectures, sensor systems and embedded renewable energy sources</li><li>• Development of <i>predictive</i> control model (incl. nDimensional data management and analysis, cleansing algorithms for sensor data)</li><li>• Development of <i>modular</i> wireless sensor platform (new, standardised protocols, new battery types for autonomous devices)</li><li>• Development of grid-based architecture to achieve load-balancing in large-scale networks</li><li>• Development of a common data model to foster interoperability between simulation tools, experimental data, building code related tools and dimensioning tools → leading to new hybrid tools for predictive energy management and optimise building operation</li><li>• Knowledge-based tools for European-wide counting of Best practice in Energy Efficiency in Construction &amp; high energy performance buildings (Network, Community of practice, ...)</li></ul>				
Results	<ul style="list-style-type: none"><li>• Hardware-software platform for integrated monitoring and control of energy systems in buildings</li><li>• Wireless, modular sensor platform to allow metering and control of small zones in buildings</li><li>• Improved wireless communication protocols compensating the draw-backs of existing industry standards, such as Zig-Bee ICT methods &amp; tools supporting optimal design of products and services with respect to energy consumption / environmental impact – e.g. dynamic building simulation tools providing information to select the best technical solutions (in terms of optimal energetic behaviour of the building)</li><li>• Feasibility study of affordable system for integration in existing buildings.</li></ul>				
Exploitation	<ul style="list-style-type: none"><li>• Provision of a reference architecture for long-term performance data management and analysis to provide information for the Life Cycle Assessment (LCA) and collaborative partnership work scenarios</li><li>• Prepare proposals for standardized interface specifications (e.g. IFC)</li><li>• Distribution of results to the relevant professional organisations</li><li>• Demonstrator projects will be made available using new constructions on University Campuses (such as ERI-building at UCC)</li><li>• Create modular, web-based training material, to be delivered to different end-user groups (SME, craftsmen, engineering personal, end-users)</li></ul>				
Impacts	<p>The energy amount used for buildings comprises over 40% of the EU’s energy consumption. This translates into approx. 30% of EU’s total CO<sub>2</sub> emissions.</p> <p>Expected energy savings through energy-efficient operation of buildings is estimated for 1/3 of total consumption → leading to approx. 13% reduction of EU’s energy consumption and 10% of EU’s total CO<sub>2</sub> emissions.</p>				
Follow-up actions	<ul style="list-style-type: none"><li>• Ensure completion of standardization (at least, continuous improvements in standards &amp; regulations)</li><li>• Increased dissemination of the developed know-how &amp; technologies, including new schemes for energy network development &amp; operation</li><li>• Deliver training courses in different modes (e.g. Master &amp; Ph.D. programmes, professional training, modules for life-long learning)</li></ul>				
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## Building Memory

Keywords	Building models, data acquisition, building performance					
Time to industry		Short term	x	Medium term		Long term
Topic area	x	7. Knowledge sharing	x	4. Intelligent constructions		
Industrial problem / relevance	In the design, construction, and operation of buildings, performance assessment and evaluation for products and services is still insufficiently established, particularly in comparison with manufacturing industries. One barrier for improved assessments of buildings is a lack of performance data and feedback/forward of such data to designers and engineers, facility operators, manufacturers, occupants, and owners. Facility Management (FM), for example, has notoriously suffered from various inefficiencies that adversely affect occupant satisfaction while at the same time causing considerable financial and environmental costs. Improperly maintained infrastructure or system failures can lead to costly delays, lower employee morale, and negatively impact the overall productivity of organizations.					
Technological objectives	This project investigates the feasibility of Building Memory system, which tracks and relates dynamic data collected by sensors distributed in facilities. Compared with existing solutions (such as energy management and control systems), the proposed Building Memory system would provide improved support to monitor, process, organize, and query sensor data. Technologies used to develop such a system include data-driven/inverse, information-rich building models, distributed data-stream management systems, spatio-temporal databases, and data mining/trend analysis.					
Approach	A Building Memory prototype system will be developed. Existing enabling technologies (building product models, datastream management, spatio-temporal db's, distributed computing such as web services) will be surveyed and adapted for the design and implementation of the prototype. The prototype system will be deployed and validated in real buildings.					
Results	Prototype system, field studies, reports/documentations (e.g. requirements, surveys)					
Exploitation	Field studies will be conducted that involve tracking of building systems (e.g. HVAC, lighting, security). Performance quality and system acceptance among facility management staff will be documented and evaluated.					
Impacts	The Building Memory system could serve to showcase the potential of providing timely,intelligent feedback and support to facility management decision-makers based on current and historical information on building performance.					
Follow-up actions	Extend the approach to field studies that involve stakeholders such as designers and engineers ('meta'-feedback).					
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## Digital Home platform and services

<b>Keywords</b>		Standards, communication, home gateway, product model			
<b>Time to industry</b>		Short term	X	Medium term	Long term
<b>Topic area</b>	x	3. Digital models	X	4. Intelligent constructions	
<b>Industrial problem / relevance</b>	<p>Smart home technologies have a huge market potential, but the demand &amp; the supply do not meet yet.</p> <p>Customers have different type of general and personalized needs: safe and secure living, productivity and expandability of user activities, and efficiency of building services (costs).</p> <p>The service of these needs can be promoted and enabled by means of smart home technologies.</p> <p>The main challenge is not the lack of technologies. Instead, products, supply chain and services should be developed to make the new solutions beneficial to the users.</p> <p>Product &amp; systems concepts and models enabling mass customisation are needed.</p>				
<b>Technological objectives</b>	<p>The project will develop new LC service concepts and models as well, enabling business models for the future digital housing and proof the concept via demonstrations and experiments. New modular product concepts, also to be developed, will be focused on intelligent space and technical systems solutions. LC management and services will be enabled by the digital home platform and building information model adapted and extended to residential applications.</p>				
<b>Approach</b>	<p>Project will be carried out by a multidisciplinary project team.</p> <p>Development and use of roadmaps for directing and scheduling RTD. Prioritisation of the alternative development options based on the stakeholders' requirements.</p> <p>Use case and scenario analysis, usability studies using demonstrators, and piloting.</p>				
<b>Results</b>	<p>Performance based housing services, space and technical system concepts, models and reference solutions for the future housing enabled by digital home platform.</p> <p>Reference model and implementation of Digital Home Platform.</p> <p>Modular mass customizable product and production technologies.</p> <p>Models and methods for knowledge based design methodology and tools.</p> <p>New business models and process definitions of mobile FM and LC services.</p>				
<b>Exploitation</b>	<p>Product and service concepts and prototypes for manufactures and construction companies, and service providers as well.</p> <p>Guidelines, templates and information on design alternatives for designers.</p> <p>Guidelines of requirements definition for building owners.</p> <p>Information on new technical possibilities and guidelines for procurement.</p>				
<b>Impacts</b>	<p>Improved performance, energy economy, home safety and security.</p> <p>New life cycle and maintenance services.</p> <p>Promotion of the breakthrough of smart home technologies</p>				
<b>Follow-up actions</b>	<p>Reference models and product models compatible with design tools.</p> <p>Guidelines and standardisation.</p>				
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**Early warning system for strategic buildings and infrastructures**

<b>Keywords</b>		Early warning, structural protection systems, seismic risk.			
<b>Time to industry</b>		Short term	X	Medium term	Long term
<b>Topic area</b>	o	3. Digital models	X	4. Intelligent constructions	o 6. Collaboration support
<b>Industrial problem / relevance</b>	Need of active structural protection systems on strategic buildings activated in case of earthquake, depending on their structural tipology and their distance from the epicentre.				
<b>Technological objectives</b>	Development of analysis and simulation tools for the early warning alert and the structural protection activation within the 20 seconds advance given by a reliable transmission system on the propagation time of seismic waves on a 100 km distance.				
<b>Approach</b>	Development of: <ul style="list-style-type: none"> <li>• environmental sensors network;</li> <li>• embedded sensors networks in the buildings;</li> <li>• data analysis and alert systems for the activation of active structural protection;</li> <li>• transmission system.</li> </ul>				
<b>Results</b>	Calibration of active structural protection systems based on structural tipology, activation time and advantage time over the seismic wave.				
<b>Exploitation</b>	The idea uses existing technology, it only tries to use it on a different way from the traditional alarm-systems.				
<b>Impacts</b>	The positive results of the research activities could bring to the wide application of both embedded sensors and protection systems on strategic and generic buildings.				
<b>Follow-up actions</b>	Standardization of both methodologies and devices, based on reliable transmission systems.				
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## Embedded sensors for the self environmental monitoring network in construction

Keywords	Sensors, energy efficiency, environment, management					
Time to industry		Short term	X	Medium term		Long term
Topic area	X	4. Intelligent constructions				
Industrial problem / relevance	The emissions and the energy consumption in public and private buildings. The high costs of the domotics systems which can monitor the emissions and the energy consumption.					
Technological objectives	The objective is to transfer in the construction field the concept of real-time global monitoring network which could reduce the emissions and increase the energy efficiency. This system should consist of low cost distributed sensors.This system can correct malpractice of the people who live in the buildings which are a great source with a huge weight in the environmental impact.					
Approach	The domotics could be integrated to a more concerning series of networks operating in the building structure ( for example: temperature, humidity sensors, etc...). This low cost network should be controlled in real-time, in order to correct the energy dispersion in large scale.					
Results	Reduction of energy consumption and the emissions, less environmental impact. An help for the people towards the environment safeguard, thanks to the low cost of the systems.					
Exploitation	The system should be low cost and user friendly and provided firstly to the new buildings, and secondly it should be integrated in the old ones.					
Impacts	The potential is a more reasonable exploitation of the energy and an huge effort for the safeguard of the environment					
Follow-up actions	The national support and dissemination together with the coordination of the construction sector with the home appliance industries. NMP work programme objective 4.4.5 call and ICT work programme objective 3.6.2.2					
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## Energy Saving through intelligent heating management

Keywords	Embedded sensors, optical fibers, distributed temperature sensing				
Time to industry		Short term	X	Medium term	Long term
Topic area	X	4. Intelligent constructions			
Industrial problem / relevance	<p>A large amount of energy is wasted due to overheating of building all around the world, or to poor thermal isolation. Efficient heating is now required for energy saving of buildings. This will participate to reduction in green house effect (Kyoto protocol), and in the same time will reduce the growth balance deficit of many European countries, as they deeply relies on fossil energy.</p> <p>An innovative domotic solution based on simple telecom optical fibers used as a continuous temperature sensor for overheating detection, heat loss detection, and in the same time fire detection!</p>				
Technological objectives	<p>Develop dedicated optical fiber cables and packaging for distributed remote sensing in structures and building (temperature).</p> <p>Test the possibility to use telecom fibers for data transmission and for temperature sensing in the same time. In that case, optical fiber cables installed in building should be used as distributed sensors, reducing the investment costs for sensing.</p> <p>Validate global concept of heating control based on distributed temperature sensing with end users. Cost benefit and cost recovery analysis.</p>				
Approach	<p>The approach will be based on light scattering in silica telecom fibers (Rayleigh, Raman or Brillouin effects). Industrial distributed sensor systems are available on the market. A comparison of performances and a choice will be done keeping in mind the end user requirements for this application. Several optical sensing cables will have to be selected and tested with respect to their embedment in structures.</p> <p>A mock up of remote distributed sensing, including feedback loop for room heating control will realised.</p>				
Results	<ul style="list-style-type: none"><li>• Specifications (end users) for such application,</li><li>• Optical fiber cable, and connecting, selection and validation,</li><li>• Methodology for optical cable embedding in structures (wall, roof, floors...),</li><li>• Mock up of intelligent heating (hardware and software) + qualification,</li><li>• Experimental validations of such smart heating on a dedicated field trial.</li></ul>				
Exploitation	<ul style="list-style-type: none"><li>• The market is potentially huge, as any existing or new building could be concerned by energy saving,</li><li>• Exploitation by potentially all heater system providers, as well as companies involved in control and electronic regulation processes,</li><li>• Industrial partners will produce sensors, as well as systems installation/maintenance.</li></ul>				
Impacts	<ul style="list-style-type: none"><li>• Will stimulate innovation in this sector, use of new technologies,</li><li>• Will offer new opportunities for innovative SME,</li><li>• Will participate to energy saving (Kyoto), and will save consumers' money.</li></ul>				
Follow-up actions	<ul style="list-style-type: none"><li>• Based on a preliminary mock-up developed and validation based on lab test and a first field trial experiment,</li><li>• Large-scale deployments – potentially in associations &amp; large organisations,</li><li>• Standardization action will have to betaken, for global use of concept, and</li><li>• Commercialisation.</li></ul>				
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## Monitoring of wooden structures

Keywords	Timber, wood, structures, monitoring				
Time to industry	X	Short term	X	Medium term	Long term
Topic area	X	4. Intelligent constructions			
Industrial problem / relevance	<p>Experience has shown that from timber houses all the way to large span sport halls, the structures need to be surveyed and/or serviced at certain intervals. The intervals are generally not specifically known.</p> <p>Recently, failures have also occurred in Finland and in other European countries. Many of these relate to timber buildings.</p> <p>Very often in large size glued laminated beams (halls, shopping malls, schools etc.) cracks develop in the structure close to the connections or in the centre span (this may be due to dry humidity's or cyclic humidity's). Some of these are dangerous and need immediate attention and strengthening actions.</p>				
Technological objectives	<p>The objective is to develop monitoring techniques and practices for remote diagnostics and serviceability control of wooden structures.</p> <ul style="list-style-type: none"><li>• Detection of excess humidity in air and in wood</li><li>• Detection of excess deformations in known critical parts</li><li>• Cracks of structures in known critical parts</li><li>• Adding information on settings on servicing and maintenance schedules, etc.</li></ul>				
Approach	The known failure cases are analysed. Cost efficient monitoring techniques are developed. Monitoring schemes are designed and demonstration buildings are followed.				
Results	Monitoring techniques and procedures for different building types developed. These will result in lower failure rates, decreased service life costs and good service life estimation methods for buildings.				
Exploitation	The work should be done in cooperation with the respective timber industry. Insurance companies should be interested in these techniques also				
Impacts	<p>The living environment will have a long and secure life span.</p> <p>The respective industries are able to claim there products to be reliable with these monitoring techniques.</p> <p>The timber building industry needs a high tech image.</p> <p>New business opportunities for servicing industries</p>				
Follow-up actions	None				
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## Self-adapting built environments

Keywords	Environmental systems, calibration, sensoric systems, energy efficiency, comfort					
Relevant to programme(s)	X	ICT		X	ENERGY	
Time to industry		Short term		X	Medium term	Long term
Topic area	X	4. Intelligent constructions				
Industrial problem / relevance	Currently, fine tuning of HVAC in large buildings takes a lot of time, even more than 1 year. Consequently, users are dissatisfied and the temperature of the building is not stable, which implies a sub-optimal energy performance of the building. For this reason a lot of money is overspend and high level of CO2 emissions are produced, but users are not comfortable.					
Technological objectives	The main objective is developing an advanced and intelligent control system that was able of self-adapting the HVAC system taking into account the users preferences and the context.					
Approach	The system will integrate the following technologies: <ul style="list-style-type: none"><li>• HVAC</li><li>• Ambient Intelligence</li><li>• Control and automatization.</li><li>• Wireless sensing.</li><li>• Energy efficiency in buildings</li><li>• Ergonomy</li></ul>					
Results	A control framework for integrated building system operation with global context awareness and friendly interaction with the users of the building.					
Exploitation	New generation of Building service systems for HVAC industry, Building management					
Impacts	Reduction of energy use, reduction of air-conditiong costs, reduction of greenhouse gases emissions, higher user satisfaction, healthier indoor environments, ...					
Follow-up actions	None					
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**Structure Monitoring based on embedded distributed sensors**

<b>Keywords</b>		Embedded sensors, optical fibers, distributed sensing, structure monitoring					
<b>Time to industry</b>		Short term	X	Medium term		Long term	
<b>Topic area</b>	X	4. Intelligent constructions					
<b>Industrial problem / relevance</b>	Monitoring of any structures, from their construction phase, life cycle, until their dismantling. The application sector includes buildings, bridges, embankments, dams, airports...						
<b>Technological objectives</b>	Develop dedicated optical fiber cables and packaging devoted to distributed remote sensing in CE structures (strain, displacement, temperature, corrosion, bending,...). Validate global concept of remote distributed sensing with end users. Cost benefit analysis.						
<b>Approach</b>	Based on optical fibers and Brillouin distributed sensing, dedicated sensors will be developed and packaged to be sensitive to the requested parameters (see above list). A commercial remote system including optoelectronics for sensor demultiplexing will be used, but a dedicated supervisor software will be develop for data analysis and storage, as well as to provide alarms if measurements exceed safety thresholds.						
<b>Results</b>	<ul style="list-style-type: none"><li>• Specifications (end users) for applications,</li><li>• Sensor prototypes, packaging,</li><li>• Definition of an industrial process to produce the sensors at an optimized cost,</li><li>• Supervisor software,</li><li>• Qualification of the complete measurement chain in laboratory,</li><li>• Field trials and validations</li></ul>						
<b>Exploitation</b>	<ul style="list-style-type: none"><li>• Exploitation by potentially all CE companies as well as building managers or maintenance concern people,</li><li>• Experience feedback associated to structure models will provide data for dedicated maintenance actions (with such technology, they will be in better position to schedule maintenance, reduce cost and risks),</li><li>• Industrial partners will produce the sensors and will provide the installation and maintenance of the systems.</li></ul>						
<b>Impacts</b>	<ul style="list-style-type: none"><li>• Better understanding on structure ageing, long term behaviour, &amp; structure health,</li><li>• Advanced maintenance procedures,</li><li>• Accurate real time measurement will provide better safety and security to users,</li><li>• Cost-effectiveness of the instrumentation and in data treatment,</li><li>• Will stimulate innovation in this sector, use of new technologies,</li><li>• Will offer new opportunities for innovative SME</li></ul>						
<b>Follow-up actions</b>	<ul style="list-style-type: none"><li>• Field trials will be undertaken, based on a preliminary mock-up and laboratory validations,</li><li>• Large-scale deployments – potentially in associations &amp; large organisations,</li><li>• Standardization actions will be taken for global use of the concept and commercialisation</li></ul>						
<b>Name</b>	Dr Pierre FERDINAND		<b>Org.</b>	CEA LIST		<b>Email</b>	pierre.ferdinand@cea.fr

**Traffic Control, roads and highways safety with optical fibers**

Keywords	Optical fibers, Weigh In Motion (WIM), ice, incident, detection						
Time to industry		Short term	X	Medium term		Long term	
Topic area	X	4. Intelligent constructions					
Industrial problem / relevance	Road traffic control in real time, including: Weight In Motion (WIM), incident and accident detection, speed control, vehicle counting and identification, ice detection for road salting. The application sector includes main roads, highways and airports.						
Technological objectives	Develop dedicated sensors to be embedded in sub surface of road cover, based on optical fiber technology. Develop dedicated software for sensors monitoring, including man-machine interface for remote control						
Approach	Based on telecom optical fibers and photo written Bragg grating in the fiber core, sensors will be developed and packaged to be sensitive to the requested parameters (weight, pressure, ice, ..). A remote dedicated system including optoelectronics for sensor demultiplexing and signal processing will interrogate the sensor network and will provide measurement and alarms in real time.						
Results	<ul style="list-style-type: none"><li>• Specifications (end users) for applications</li><li>• Sensor prototypes, System + software</li><li>• Qualification of the complete measurement chain in laboratory</li><li>• Field validations</li></ul>						
Exploitation	<ul style="list-style-type: none"><li>• Highway companies, as well as airport managers,</li><li>• With such technology, they will be in better position to control secured traffic,</li><li>• Industrial partners will produce sensors and remote systems, and provide installation and maintenance of systems on field.</li></ul>						
Impacts	<ul style="list-style-type: none"><li>• Accurate real time measurement will provide better safety and security to users, will provide an input for preventive action in case of traffic jam (entrance regulation). Should be used to determine fees for trucks (versus weight), or to detect over weight.</li><li>• Will stimulate innovation in this sector, use of new technologies,</li><li>• Will offer new opportunities for innovative SME</li></ul>						
Follow-up actions	<ul style="list-style-type: none"><li>• Based on a preliminary mock-up developed and validation based on lab test and a first field trial experiment,</li><li>• Large-scale deployments – potentially in associations &amp; large organisations</li><li>• Standardization action will have to be taken, then global use of the approach.</li></ul>						
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## Europe goes Zero – Advanced European EE Buildings

<b>Objectives: -</b> <ul style="list-style-type: none"> <li>• Double the energy efficiency in the building stock in 2020</li> <li>• Towards zero energy consumption in buildings</li> <li>• Increase the awareness and motivation for energy saving measures of the public, the communities and the industry</li> <li>• Enforce energy performance requirements for new and existing buildings</li> <li>• Realise demonstration projects for high efficient and zero energy buildings all over Europe</li> </ul>	
<b>Scope:</b> <ul style="list-style-type: none"> <li>• Develop a framework for demonstration buildings and promotion platforms for different type of target audiences.</li> <li>• Form interest groups out of industry, communities, designers, research organisations and policy makers.</li> <li>• Planning, realisation and evaluation of demonstration buildings.</li> <li>• Cross evaluation of monitoring results and project results</li> <li>• Analyse barriers and needs at the market implementation process of innovative technologies, components and building concepts</li> <li>• Develop marketing guides and information portals for high efficient buildings</li> </ul>	
<b>Proposed funding instrument:</b> EU-funds (projects with EC-contributions), industrial co-funding	<b>Tentative budget:</b> 250 M€
<b>Additional partner organizations needed:</b> <i>[branch]</i> <ul style="list-style-type: none"> <li>• industry</li> <li>• communities</li> <li>• international research organisations</li> </ul>	
<b>Contact person:</b> <b>Name:</b> Hans Erhorn <b>Address:</b> Fraunhofer Institute of Building Physics, Nobelstr. 12, 70569 Stuttgart, Germany <b>Phone:</b> +49-711-970-3380 <b>Fax:</b> + 49-711-970-3399 <b>E-mail:</b> hans.erhorn@ibp.fraunhofer.de	

## LowEx Communities - Towards a more sustainable society

### **Objectives:** -

The main objective of the proposed action is the concept development and demonstration of exergy distribution, generation and storage systems that meet all exergy demands of community members with a minimum input of primary energy.

Exergy is a concept which helps us distinguish between two parts of an energy flow: exergy and anergy. Only the exergy part of any energy flow can be converted into some kind of high-grade energy such as mechanical work or electricity. Anergy, on the other hand, refers to the part of the energy flow which cannot be converted into high-grade energy (e.g. low-grade waste heat from a power plant). Exergy can be regarded as the valuable part of energy, while anergy designates the low-value portion. The Low Exergy (LowEx) approach entails matching the quality levels of exergy supply and demand, in order to streamline the utilisation of high-value energy resources and minimise the irreversible dissipation of low-value energy into the environment.

### **Scope:**

To reach these general objective the following strategic objectives have to be fulfilled. As there are:

- The demonstration of the use of low valued renewable energy sources for heating and cooling of buildings (based on low exergy principles), facilitated by an integrated design of buildings and energy concepts.
- The demonstration of the economic viability and sustainability of the local use of low valued energy sources. The scale is that of a whole community or housing district.
- The contribution to EC energy objectives (such as CO<sub>2</sub>-reduction and security of energy supply);
- The development of innovative technologies for energy supply structures at different energy levels and advanced system concepts or solutions for the distribution, local generation, the local utilisation of renewable and ambient resources, and storage of energy/exergy.
- The demonstration of the contribution of the used technology and communication approaches for the development of sustainable LowEx communities to prepare the next steps in the further market development;

**Proposed funding instrument:** EU-funds  
(projects with EC-contributions), industrial co-funding

**Tentative budget:** 250 M€

### **Additional partner organizations needed:** *[branch]*

- communities
- international research organisations
- industry (district heating and cooling, storage)
- planners (integral lowex system planners)

### **Contact person:**

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## Interoperability

Strategic Action	Objectives
<b>Construction of common domain specific transaction protocol</b>	Develop a <b>guideline/specification</b> for practitioners in ICT for the building industry of an implementation-neutral set of interactions for common operations and processes across all sub-domains.
<b>Extension of IFC for Roads and Civil Engineering</b>	A measurable achievement will be ability to consistently see building, road and civil engineering 'constructions' including all shape and property information via a consistent interface (browser). This will include 'on demand' serving of information from potentially multiple sources into a common browsing environment.
<b>Integrative Structural Dynamics</b>	<p><b>Objective 1 – Global Ontology:</b> An ontology is primarily a way for a community to agree upon the meanings of terms and relations so that they may reliably share knowledge and information. With terms and relations thus defined, automated processes that share this common definition can perform simple reasoning. The Vienna Consulting Engineers recognized the need of an ontology for Structural Dynamics to join the efforts for the establishment of a common knowledge-base and enable the collaborative research dedicated to Structural Dynamics and Structural Health Monitoring.</p> <p><b>Objective 2 – Establishment of Network:</b> A network of members from Universities, Research Institutions, Laboratories, Engineering consultants and construction companies has to be established as a R&amp;D and Testing platform.</p> <p><b>Objective 3 – IT-Infrastructure for collaborative testing (distributed laboratory) and data exchange:</b> The objective is formulated in a very general manner since the development of various tools is required. Interfaces such as XML communication Protocols or standardized data format as well as tools like tele-presence and tele-control, image analysis, multi-lab simulation and analysis, data repository and many more. The realisation of objective 3 requires a very close collaboration between civil engineers and IT professionals.</p>

**Construction of common domain specific transaction protocol**

Keywords		SOA, (Semantic) Web Services, Building Information Model				
Time to industry		Short term	X	Medium term		Long term
Topic area	X	5. Interoperability				
Industrial problem / relevance	Each web service provider and consumer (agent) has different set of possible interactions. Implementers / users of web-service clients face high manual workload. Interoperability is often limited by high diversity. Existing interoperability developments focus mainly on the content models (BIMs), specifications/guidelines for interactions are sparse					
Technological objectives	Develop a guideline/specification for practitioners in ICT for the building industry of an implementation-neutral set of interactions for common operations and processes across all sub-domains.					
Approach	Based on existing (certified) transaction protocols, e.g. ebXML, BPEL4WS or their semantically enhanced counterparts: develop AEC/FM – specific extensions that take different practices in Europe into account and unify them					
Results	Specification documents, template library, API, exemplary transactions, test-suits.					
Exploitation	Small- to middle-sized enterprises in the ICT for AEC get unified interaction protocols/tools/APIs as basis of their interoperability interfaces. Implementation effort to integrate their legacy product into a SOA is reduced					
Impacts	Tighter integration of different building domains, better coordination of business processes, enhanced interoperability among (European) businesses					
Follow-up actions		None				
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## Extension of IFC for Roads and Civil Engineering

<b>Keywords</b>	IFC, interoperability, ontology, roads, civil engineering		
<b>Relevant to programme(s)</b>	✓ ICT	✓ ENVIRONMENT	✓ TRANSPORT
	✓ EUREKA	✓ ERABUILD	
<b>Time to industry</b>	✓ Short term	Medium term	Long term
<b>Topic area</b>	✓ 3. Digital models	✓ 5. Interoperability	✓ 6. Collaboration support
<b>Industrial problem / relevance</b>	Organizations within the construction industry are often involved in design, construction and maintenance for buildings, roads and civil engineering. The processes involved are similar. In many cases, such organizations have a need to either hold the information about all types of construction in a common form or to exchange information between applications specializing in particular types of construction. Additionally, public organizations need to establish data structures that can deal in common with geographic, road and building information.		
<b>Technological objectives</b>	A measurable achievement will be ability to consistently see building, road and civil engineering 'constructions' including all shape and property information via a consistent interface (browser). This will include 'on demand' serving of information from potentially multiple sources into a common browsing environment.		
<b>Approach</b>	<p>The approach will be to review existing work on specification of building, road, bridge, geographic and civil engineering requirements. This will cover international and national needs.</p> <p>The aim is then to determine how these developments can be merged or (more probably) used together to satisfy industry requirements for common, consistent and reliable access to infrastructure data.</p> <p>The approach recognizes the richness of the IFC model to provide detailed information across a facility lifecycle. Additionally, landXML is recognized as also is transXML in the broader context of transportation and CityGML in the common interfacing of city-maps, buildings and roads. Definition of interfaces between IFC and these specifications is therefore within the scope of this project.</p>		
<b>Results</b>	<p>Software applications across the different 'infrastructure' disciplines will be able to exchange relevant sets of information according to the level of detail required.</p> <p>A common approach to checking designs/constructions for conformance with regulations systems will be developed</p>		
<b>Exploitation</b>	<p>Solutions will be provided in the form of open source models and open source data access specifications (web services, grid access).</p> <p>User support will be through the provision of controllable process maps that work with software applications and that conform to industry standard description methods.</p> <p>Software developer support will be through the provision of 'patterns of commonly used information' delivered as business process objects.</p>		
<b>Impacts</b>	<p>Better support to early stage design and decision making across the entire infrastructure</p> <p>Consistent description of information across road, planning and building agencies within national and local government enabling easier and more effective access to up to date information and supporting better planning of services and maintenance needs.</p>		
<b>Follow-up actions</b>	Establishment of a detailed scope and work plan. Extended support to facilitate the development.		
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## Integrative Structural Dynamics

<b>Keywords</b> Ontology, Data Standardisation, Data Exchange, Collaborative Testing, Distributed Laboratory										
<b>Time to industry</b>			Short term		x	Medium term		Long term		
<b>Topic area</b>		x	5. Interoperability		x	6. Collaboration support		x	7. Knowledge sharing	
<b>Industrial problem / relevance</b>		<p>Institutions and communities dedicated to research in the field of Structural Dynamics have its origin in civil engineering, fluid dynamics, earthquake engineering and other related science. Therefore and the fact that research in structural dynamics started around the globe resulted in many standards and terminologies which makes applied exchange of knowledge and data very difficult.</p> <p>“People can’t share knowledge if they don’t speak a common language” –<i>T. Davenport, L. Prusak, Working Knowledge, Harvard Business School Press, 1998.</i></p> <p>Collaborative research activities and bundling of resources for laboratory testing or dynamic analysis for more competitiveness is not possible yet.</p> <p>In the US and Japan there are programmes ongoing to set up countrywide standards which will make national collaboration possible.</p> <p>However, there is no European strategy to sustainable increase the effectiveness of R&amp;D activities in earthquake engineering and structural dynamics.</p>								
<b>Technological objectives</b>		<p><b>Objective 1 – Global Ontology:</b> An ontology is primarily a way for a community to agree upon the meanings of terms and relations so that they may reliably share knowledge and information. With terms and relations thus defined, automated processes that share this common definition can perform simple reasoning. The Vienna Consulting Engineers recognized the need of an ontology for Structural Dynamics to join the efforts for the establishment of a common knowledgebase and enable the collaborative research dedicated to Structural Dynamics and Structural Health Monitoring.</p> <p><b>Objective 2 – Establishment of Network:</b> A network of members from Universities, Research Institutions, Laboratories, Engineering consultants and construction companies has to be established as a R&amp;D and Testing platform.</p> <p><b>Objective 3 – IT-Infrastructure for collaborative testing (distributed laboratory) and data exchange:</b> The objective is formulated in a very general manner since the development of various tools is required. Interfaces such as XML communication Protocols or standardized data format as well as tools like tele-presence and tele-control, image analysis, multi-lab simulation and analysis, data repository and many more. The realisation of objective 3 requires a very close collaboration between civil engineers and IT professionals.</p>								
<b>Approach</b>		<p>The international readiness was already recognised in earlier efforts of the SAMCO Network and I-SAMCO initiative.</p> <p>Contact to international key players is already established.</p> <p>International state-of-the-art and current practices have to be identified.</p> <p>Political Obstacles have to be debilitated-</p> <p>A European and international strategy to efficiently achieve the defined objectives.</p>				<p>Technology and Know-How is available. Interfaces such as general data models and protocols have to be defined.</p> <p>A good example can be seen in biogenetics where small companies, universities and big group work effective in an environment where results and knowledge can be shared easily in a very complex field.</p>				
<b>Results</b>		<p>The development of various tools is required. Interfaces such as XML communication Protocols or standardized data format as well as tools like tele-presence and tele-control, image analysis, multi-lab simulation and analysis, data repository and many more. The realisation of objective 3 requires a very close collaboration between civil engineers and IT professionals.</p>								
<b>Exploitation</b>		<p>A network of members from Universities, Research Institutions, Laboratories, Engineering consultants and construction companies has to be established as a R&amp;D and Testing platform.</p>								
<b>Impacts</b>		<p>Major output should hit the society since research in civil engineering, especially earthquake engineering contributes essentially to the safety and protection of citizen.</p>				<p>Economic impact due to effectiveness of research and development activities (increased output per Euro spent).</p>				
<b>Follow-up actions</b>		<i>None</i>								
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## Collaboration Support

Strategic Action	Objectives
<b>A Project-oriented Virtual Meeting Point (VMP)</b>	<p>The objective will be the creation of an <b>immersive virtual meeting point</b>, which automatic traceability of the meeting decisions.</p> <p>Current collaborative environment are mainly videoconference systems, emails or shared libraries of documents.</p> <p>The VMP will integrate synchronous and asynchronous communication mechanisms with advanced virtual reality technologies, in such a way that the all the information about the project (documents, CAE and Virtual Reality models, ...) is available during the meeting and changes and decisions are automatically traced in a secure way</p>
<b>Collaborative Working Environments for Mass Housing Design and Construction</b>	<p>In order to achieve and effective integration of ICT it is necessary to operate simultaneously at different levels: 1. progressing in the implementation of standards that facilitate building information exchange; 2. structuring the information about building components so that it can be easily accessible by information systems and facilitating interoperability across platforms; 3. developing <b>integrated, scalable computerized environments</b> which would allow a group of stakeholders to work together in an efficient manner, throughout the whole design and construction stages of a mass housing project. The research work would focus primarily on the third level. Whereas much work is being done in order to set up building information models and to make product information accessible through information systems, it still remains necessary to envision appropriate working environments which enable design and construction teams to develop a project collaboratively in an efficient manner, especially housing projects.</p>
<b>Impact of Digital Model Techs on Work Practice</b>	<p>Data will be collected from existing projects to measure the current impact of digital modelling technologies on planner productivity and project quality. Based on these results, a <b>decision support tool</b> will be developed that supports cost-benefit analysis of digital modelling technologies and related work processes at a firm, project, and project team level. The tool should be able to estimate the combined impact of changes in work practices and/or changes in digital modelling technologies. These are multi-criterion optimization problems (worker productivity, modelling technology complexity, training hours, inter-operability levels, number of tasks etc. may be among the input parameters).</p>
<b>Integrated Informatics System of Construction Investment Process Management</b>	<p>The aim of the project is to create integrated informatics system of construction investment process management. The system would cover all participants of construction investment – from the investors and designers, through investors' inspection of executors and their subcontractors, to the suppliers. Application of the mobile technology in the system could lead to increase in the speed of data flow and then, as a result, to increase in the tempo and accuracy of decisions taken by management.</p>
<b>New visualization interfaces dedicated to coordination of building construction</b>	<p>Using IFC/XML format to describe different "dimensions" of coordination.</p> <p>Developing Web Services architecture.</p> <p>Model Driven Engineering-based development (transformation, models mapping).</p>
<b>Pervasive document and information sharing</b>	<p>A set of metadata should be directly inserted in the files shared all along the collaborative process, an objective will be to create some tools able to exploit the metadata already present in each software.</p> <p>Start an integration of these datasets in the IFC</p>
<b>Semantic Collaborative Modelling Space for CE</b>	<p>Based on technologies related to the Semantic Web and Collaborative environments (blogs, wikis, etc.), a <b>Semantic Collaborative Modelling environment</b> (potentially including a Web Portal for community vision &amp; roadmap) and tools supporting the description and sharing of "open source" engineering concepts in the context of interactions between multi-disciplinary actors.</p>
<b>Steering system for design process in architecture</b>	<p>An <b>environment able to integrate the set of various software applications</b> aiming to run and steer the overall collaborative Design Process in Architecture.</p>
<b>Trust in collaboration</b>	<p>Enforcing the quality of information diffusion and reliability</p> <p>Overtaken exchange reluctance in project teams.</p>
<b>Virtual collaborative workspace for mobile workers</b>	<p>An <b>environment (a virtual workplace)</b> that provides mobile workers with context-based asynchronous and synchronous basic &amp; advanced collaborative services, e.g. terminal and network adaptation, secure communication, smart access to all project documentation, vertical services for instant collaboration and remote decision, etc.</p>

## A Project-oriented Virtual Meeting Point (VMP)

Keywords		Immersive environment; project management; decision tracking						
Relevant to programme(s)		X	ICT					
Time to industry			Short term		X	Medium term		Long term
Topic area		X	6. Collaboration support					
Industrial problem / relevance		Construction work teams need increasing their interactivity without any restriction or limitation derived of their geographical dispersion and mobility. Interactions between actors are still not well co-ordinated, especially because of the inherent dynamic business relationships taking place in the construction industry. If the interactivity is increased, projects will be developed faster and their quality will be increased.						
Technological objectives		The objective will be the creation of an <b>immersive virtual meeting point</b> , which automatic traceability of the meeting decisions. Current collaborative environment are mainly videoconference systems, emails or shared libraries of documents. The VMP will integrate synchronous and asynchronous communication mechanisms with advanced virtual reality technologies, in such a way that the all the information about the project (documents, CAE and Virtual Reality models, ...) is available during the meeting and changes and decisions are automatically traced in a secure way.						
Approach		The system will be based on a shared project library (documents, CAE models) and other CSCW tools, which will be integrated with a friendly user interface, based on Ambient Intelligence and Virtual Reality technologies, that makes possible the co-operation of heterogeneous actors and close the loop Documents/CAE Models -> VR Models -> Documents/CAE Models CAE Models.						
Results		Virtual workspace to make possible project meetings with project team members (client, promoter, architects, ...) without any restriction due to the geographical dispersion in order to improve data flow between the different stakeholders..						
Exploitation		The result will be exploited as any other advanced communication equipment by telecommunications companies, services providers. The customer of the product will be large real state managers and main contractors, but the final user will be any actor in the construction process.						
Impacts		Cost-reductions, knowledge-based enterprise (knowledge and people always is available), higher quality in construction products and reduction and tight control of the project duration through an effective process progress monitoring.						
Follow-up actions		Standardization of metadata about project documents and models and standardization of the CAE models (i.e., IFC).						
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## Collaborative Working Environments for Mass Housing Design and Construction

Keywords	Housing, industrialized construction, building integrated models, collaborative work					
Time to industry		Short term	x	Medium term		Long term
Topic area	x	2. Industrialised production	x	3. Digital models	x	6. Collaboration support
Industrial problem / relevance	As the European integration progresses at the social, political and economic levels, the need to address housing construction at a European scale becomes more urgent. Even though a European construction industry is slowly emerging around the integration of building subsystems, design and construction processes are still very much determined by local conditions, especially with regard to mass housing. An effective integration of ICT in housing design and construction would contribute to overcome the limitations imposed by the fragmentation of the construction sector and its dependency from local (geographic, economic) factors. New forms of organization facilitated by the working spaces supported by ICT, would do away with established working procedures, replacing the prevailing sequential and linear processes still by more permeable and interconnected working methods which would favor the interaction among different stakeholders in the design and construction of mass housing, throughout the whole building lifecycle. The overall goal of this research work is to promote a system approach towards the problem of housing, with favors the integration of ICT in this construction sector.					
Technological objectives	In order to achieve an effective integration of ICT it is necessary to operate simultaneously at different levels: 1. progressing in the implementation of standards that facilitate building information exchange; 2. structuring the information about building components so that it can be easily accessible by information systems and facilitating interoperability across platforms; 3. developing integrated, scalable computerized environments which would allow a group of stakeholders to work together in an efficient manner, throughout the whole design and construction stages of a mass housing project. The research work would focus primarily on the third level. Whereas much work is being done in order to set up building information models and to make product information accessible through information systems, it still remains necessary to envision appropriate working environments which enable design and construction teams to develop a project collaboratively in an efficient manner, especially housing projects.					
Approach	The objective is to create a platform to promote the interaction among all stakeholders participating in the design and construction of mass housing throughout the whole building lifecycle. This platform would facilitate: 1. automatic generation of design solutions (housing layouts, housing aggregations) which will give rise to a knowledge-based system; 2. the integration of the design and construction processes around a building integrated model (knowledge-specific data extraction; building as assembly of components); 3. the communication among the stakeholders taking part in the processes, from design to construction, and from maintenance to demolition (customization of housing layouts with participation of users; integration of industrialized building components accessible from digital repositories; monitoring of building performance though computer model). The platform will have a modular architecture, and it will be based on existing technologies (web services, .NET, XML schemas), and it will support standards being developed by IAI and IFC. Batch processing might be used to generate and search optimal design solutions (housing layouts, blocks,...).					
Results	A comprehensive, integrated web-based platform which would provide working spaces to enable a group of stakeholders (developers, architects, tenants, contractors) to initiate, develop and build a housing project. The platform will comprise: 1. Interfaces to capture the inputs of future occupants so that their insights are part of the system-driven design process 2. Generation of housing layouts and housing aggregations (blocks, towers, row-houses) carried out in interaction with design agents (architects, occupants, manufacturers) 3. Optimization methods to find housing layouts and housing aggregates that better meet design and performance values 4. Interfaces to access building component libraries during the design and construction stages 5. Ad-hoc procedures to facilitate communication throughout the different stages of the design and construction (from computer modelling to manufacturing) 6. A three-dimensional environment to monitor building performance and facilities management.					
Exploitation	Free access to the platform will be provided to any group of stakeholders who are willing to initiate and develop with it a housing project at any location in Europe. Manufacturers of building components and subsystems would be actively involved in the integration of their products in the design and construction processes. Housing projects promoted by public administrations or private-public partnerships could serve as case studies for the application of the platform. Further support and development of the system will be financed by housing consortiums which make use of it.					
Impacts	It will encourage the different stakeholders participating in housing projects to find alternative forms of organization and collaboration using ICT. It will provide motivations to architects, building manufacturers, administrators and contractors to develop collaborative working procedures which will contribute to overcome the traditional fragmentation of the construction industry. When it is effectively applied, it will stimulate progress in the implementation of standards and product modelling in the building sector.					
Follow-up actions	Housing projects of middle size (50-300 units) will serve as case studies to test the functionality of the environment.					
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Organisation	ARC Enginyeria i Arquitectura La Salle- Universitat Ramon Llull, Barcelona					



## Impact of Digital Model Technologies on Work Practice

Keywords	Digital models, work practice, product quality				
Time to industry		Short term		Medium term	x Long term
Topic area	x	3. Digital models			
Industrial problem / relevance	New digital modeling, technologies are being developed, but work practices to exploit these lag far behind. This gap in technology adoption to enhance productivity of workers and the quality of products is particularly pronounced in the AEC industry for well-known reasons.				
Technological objectives	Data will be collected from existing projects to measure the current impact of digital modelling technologies on planner productivity and project quality. Based on these results, a decision support tool will be developed that supports cost-benefit analysis of digital modelling technologies and related work processes at a firm, project, and project team level. The tool should be able to estimate the combined impact of changes in work practices and/or changes in digital modelling technologies. These are multi-criterion optimization problems (worker productivity, modelling technology complexity, training hours, inter-operability levels, number of tasks etc. may be among the input parameters).				
Approach	Benchmarking studies are proposed to study existing work practices, especially in the design phase where the need for coordination is greatest and modelling technologies have highest impact. Key performance indicators are defined and organisational and process modelling tools are used in benchmarking, subsequent data analysis and tool development. Analysis techniques are developed that take into account the risk associated with using innovative new technologies (e.g. different levels of inter-operability might have different risks/probabilities of problems occurring during use).				
Results	Metrics for measurable improvements in the organisational / process effectiveness using emerging digital model technologies supported by data are developed. Tools supporting decision support for deployment of digital modelling technology at different organizational levels are available for use. The project results in a better understanding of how to realize the potential of digital model technologies on work practices in the AEC sector.				
Exploitation	Tools, process models, reports. Immediate tool users would be personnel responsible for IT planning in AEC companies. In a wider sense, tools are used to support management decision-making.				
Impacts	Improved awareness for the impact of digital building modelling backed up by empirical data. Improved work practices and quality of construction services.				
Follow-up actions	None				
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## Integrated Informatics System of Construction Investment Process Management

Project objectives		Relevant to programme:	X	EurekaBuild
The aim of the project is to create integrated informatics system of construction investment process management. The system would cover all participants of construction investment – from the investors and designers, through investors’ inspection of executors and their subcontractors, to the suppliers. Application of the mobile technology in the system could lead to increase in the speed of data flow and then, as a result, to increase in the tempo and accuracy of decisions taken by management.				
Stage I – Modeling and designing		Participants:		
Analysing and building up the model of integrated informatics system of construction investment process management by using the UML diagrams (partner countries)		Analytics and Designers of informatics systems and Experts.		
Attempt of identification the common elements in the model of integrated system of construction investment management.		Analytics and Designers of informatics systems and Programmers.		
Selection of the programming technology		Programmers		
Stage II – Implementation				
Databases		Database Programmers		
Software		Programmers		
Stage III – Implementation, tests and changes				
Implementation		Implementation firms/ companies		
Testing and evaluation of the system		Experts		
Introducing changes to the system model		Analytics, Designers and Programmers		
Implementation of accepted changes		Programmers		
Potential impact (economic, environment, social, other ...)				
-shorten time of the investment and as the result the costs of realization -make/ create the conditions which let to consolidate all participants of construction investment process -introduce the standard of the construction investment project’s integrated management (improve of international projects) -better control of quality and time of work execution at different levels -fast, easy and remote access to information at different decisions making levels.				
Market application and exploitation				
The project’s main target group are: executive companies and other participants of the process of the construction investment project management.				
Partner expertise	Estimated duration	Estimated budget (in Euro)		
	36 months	About 1,5M EUR (depends on the number of partners)		
Partner contribution to the project (financial, technological,...)				
American Systems of Marketing will realize the stage of the system implementation. It will also participate in the final stage of the system’s analyzing and designing. Moreover, after the software testing, ASM will realize possible implementation changes in the system.				
Type of contribution searched(financial, technological,...)				
- informatics or consulting companies involved in designing of informatics system by using UML - companies that have the experience in implementation and managing of integrated informatics systems Experts: - contractors - building supervision companies - designing companies - architects				
Name	Robert Bagiński	Email	r.baginski@american-systems.pl	Org American Systems of Marketing



## New visualization interfaces dedicated to coordination of building construction

Keywords	Coordination, Human-Machine Interaction, Information Visualization				
Time to industry	x	Short term		Medium term	Long term
Topic area	x	6. Collaboration support			
Industrial problem / relevance	Addressing coordination problems during building construction activities. Focusing on information overload, redundancy and contradictions. Linking pieces of information coming from different sources (tools, documents). Allowing the actors to identify more precisely coordination problems using their usual documents and tools.				
Technological objectives	Using IFC/XML format to describe different “dimensions” of coordination. Developing Web Services architecture. Model Driven Engineering-based development (transformation, models mapping).				
Approach	Developing a groupware dedicated to building construction. Designing new interfaces to visualize information.				
Results	A tool adaptable to the user’s need(s): personalization, evolving architecture. An innovative visualization interface.				
Exploitation	Proposition of services. “Re-usable” and integrative architecture.				
Impacts	Favouring a better comprehension of activity by the actors to increase cooperation quality and mutual adjustment. Reducing the number of coordination problems by their anticipation.				
Follow-up actions	None				
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## Pervasive document and information sharing

Keywords	Virtual teams; intranet / extranet; groupware				
Time to industry	X	Short term		Medium term	Long term
Topic area	X	6. Collaboration support			
Industrial problem / relevance	<p>Seamless exchange</p> <p>Collaboration implies several file conversions (even with IFC) and multiple forms to be filled. Most of the time information exchange is driven by a deadline in the project. In this case, form filling is seen as cost consuming and useless by the users of a groupware tool. Thus the quality of the metadatas and the information attached to the documents is minimal.</p>				
Technological objectives	<p>A set of metadata should be directly inserted in the files shared all along the collaborative process, an objective will be to create some tools able to exploit the metadata already present in each software.</p> <p>Start an integration of these datasets in the IFC</p>				
Approach	<p>Collect these metatdata all along the design and building process in order to accelerate the sharing step.</p> <p>Create or use an ontology to generate coherent metadata's for all the project partners.</p>				
Results	<p>Tagging all the files that can be shared in a project will accelerate the diffusion and indexation process.</p>				
Exploitation	<p>Extend the usage collaborative tools to SME, strengthen the information flow in the projects by the usage of metadata and ontology.</p>				
Impacts	<p>Empower the exchange in the projects.</p> <p>Extend collaborative efficiency to SME.</p>				
Follow-up actions	AEC and collaboration ontology				
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## Semantic Collaborative Modelling Space for CE

<b>Keywords</b> (max 5)	Engineering semantic space, Knowledge Community for Collaborative (semantic) Modelling, shared "open-source"-like Engineering concepts					
<b>Time to industry</b>		Short term	X	Medium term		Long term
<b>Topic area</b>	o	3. Digital models	X	6. Collaboration support	o	7. Knowledge sharing
<b>Industrial problem / relevance</b>	<ul style="list-style-type: none"> <li>• Need of semantic-based collaboration services &amp; processes for design &amp; engineering, based on <i>semantically enriched engineering concepts</i>.</li> <li>• Need for Plug&amp;Play collaboration among trading partners through better understanding, a closer dialogue and active cooperation between end-users/practitioners and solution/technology-suppliers through community building activities dealing with semantics &amp; knowledge communication/sharing.</li> </ul>					
<b>Technological objectives</b>	Based on technologies related to the Semantic Web and Collaborative environments (blogs, wikis, etc.), a Semantic Collaborative Modelling environment (potentially including a Web Portal for community vision & roadmap) and tools supporting the description and sharing of “open source” engineering concepts in the context of interactions between multi-disciplinary actors.					
<b>Approach</b>	<ul style="list-style-type: none"> <li>• Generic semantic collaborative modelling approach, applied to the AEC domain.</li> <li>• Baseline technology of this R&amp;D is all technology dealing with semantics, taxonomies &amp; ontologies, moreover coupled with the Semantic Web standards.</li> <li>• Need to bring together expertise from the SKT and AEC<sup>13</sup> communities, and to proceed by successive incremental experimentation.</li> </ul>					
<b>Results</b>	<ul style="list-style-type: none"> <li>• A <b><i>Semantic Collaborative Modelling environment</i></b> of “open source” Engineering Concepts to experiment effective semantic collaborative modelling tools (Web oriented Mind-mapping &amp; activity modelling) for the description &amp; sharing of engineering concepts within an “open source modelling movement”.</li> </ul>					
<b>Exploitation</b>	<ul style="list-style-type: none"> <li>• Exploitation by potentially all engineers (and even other actors like architects) for control of and access to relevant and trusted semantic engineering information, to further develop semantically enhanced applications &amp; services.</li> <li>• Shared semantically described engineering concepts will be used to increase creativity potential and innovation capacity as well as business opportunities.</li> </ul>					
<b>Impacts</b>	<ul style="list-style-type: none"> <li>• Stimulation of the innovative use of SKT in the AEC domain enabling Plug&amp;Play collaboration among trading partners through semantically enriched information (engineering concepts) - especially at level of SMEs innovation</li> <li>• Increase of creativity potential and innovation capacity as well as emergence of business opportunities based on the exploitation of complex semantic knowledge spaces supporting Concurrent Engineering in AEC.</li> </ul>					
<b>Follow-up actions</b>	<ul style="list-style-type: none"> <li>• Based on a preliminary mock-up developed in some R&amp;D project, experimentation within small groups, then generalisation of the approach.</li> <li>• Interfaces and add-ons for accessing through specialised engineering tools.</li> <li>• Large-scale deployments – potentially in associations &amp; large organisations</li> </ul>					
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<sup>13</sup> SKT: Semantic Knowledge Technology; AEC: Architecture, Engineering & Construction.

**Steering system for design process in architecture**

<b>Keywords</b> (max 5)		Design process in architecture, steering of the design process, dashboard, Key Performance Indicators					
<b>Time to industry</b>			Short term	X	Medium term		Long term
<b>Topic area</b>	Process :	X	1. Value-driven business processes				2. Industrialised production
	Product :		3. Digital models				4. Intelligent constructions
	Project :		5. Interoperability			X	6. Collaboration support
	Enterprise :		7. Knowledge sharing				8. ICT enabled business models
<b>Industrial problem / relevance</b>		Nowadays, the actors involved in the design in architecture are facing the increasing complexity of projects, due to their collaborative context. To ensure the control of this complexity, it is mandatory to provide the actors with a software solution able to easily and coherently represent and check the context of the project.					
<b>Technological objectives</b>		An environment able to integrate the set of various software applications aiming to run and steer the overall collaborative Design Process in Architecture.					
<b>Approach</b>		Work out a development step similar to the “Software factory” approach: a model driven approach for the modelling of design processes (MDE, "Model Driven Engineering"), an execution model compatible with the standards of workflow like BPEL ("Business Process Language Execution"), an extensible execution engine using programming by aspect (AOP – <i>Aspect Oriented Programming</i> ).					
<b>Results</b>		<ul style="list-style-type: none"><li>• A steering-driven metamodel of design process in architecture;</li><li>• A set of functional specifications for design services and control indicators;</li><li>• A graphic modeller of design process allowing description, stabilization and validation of the design (business) model;</li><li>• A Tool based on SOA (Services Oriented Architecture) with 3 modules: Modelling module, Process execution module and Service development module.</li></ul>					
<b>Exploitation</b>		<ul style="list-style-type: none"><li>• Design managers are looking to design snapshots, an overview of what is going on.</li><li>• Business users can see theirs individual business process or sub-process in connection with reports and interactive analyzes.</li></ul>					
<b>Impacts</b>		<ul style="list-style-type: none"><li>• Allow the whole perception of design processes by ascertaining its dynamics. Thus the project manager will be able to make the adequate decisions &amp; trade-offs to reach the expected performance;</li><li>• Memorize and channel the dynamics produced during the design process, which consequently influence the future actions;</li><li>• Provide all (sub-)processes states at any moment of the project in the design phase;</li><li>• Quantify the achievement of the objectives of the architectural design project;</li><li>• Assist the anticipation of potential dysfunctions related to the processes.</li></ul>					
<b>Follow-up actions</b>		Interfaces and add-ons for popular tools (e.g. CAD tools, electronic mock-ups, etc.). Standardization of design (business) models. Bridging gap with business software by SOA/EAI layer.					
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**Trust in collaboration**

Keywords	Trust; Virtual teams; groupwares; human resource involvement					
Time to industry		Short term	X	Medium term		Long term
Topic area	X	6. Collaboration support				
Industrial problem / relevance	<b>Trust and confidence in virtual teams</b>					
	How is it possible to reinforce or preserve the existing trust by usage of technologies? In heterogeneous teams, groupwares are significantly impacting trust issues: how can we take the best ?					
Technological objectives	Enforcing the quality of information diffusion and reliability Overtaken exchange reluctance in project teams					
Approach	Define key factors of trust in AEC field Build a trust efficient model upon AEC standards Metadata and processes related to trust and evaluation framework					
Results	Trust modelling and key indicators to evaluate collaborative situations Software architecture aimed to build trusted collaboration including rights management, intellectual property and data annotation and diffusion. Tailoring the collaboration support system by using a requirement engineering suite.					
Exploitation	Addons to existing platforms Web services Social network design and animation support					
Impacts	Identify and solve collaboration lacks at their early stages Increase collaboration quality and performance Strengthen relationships in virtual communities					
Follow-up actions	Business process analysis and related standards applied to AEC					
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**Virtual collaborative workspace for mobile workers**

<b>Keywords</b>		Virtual office, mobility, ambient technologies, collaboration support, adaptive systems															
<b>Time to industry</b>					Short term		X	Medium term				Long term					
<b>Topic area</b>		X	1. Value-driven bus. processes					X	3. Digital models			X	6. Collaboration support				
<b>Industrial problem / relevance</b>		<ul style="list-style-type: none"><li>Construction practitioners need to have their working environment at disposal anywhere and anytime, even when they are mobile. Solutions should be individualized, context-sensitive (based on device and network capabilities, user profile, user role &amp; activities, project context, etc.), and allow secure access to, and/or real-time exchange and dynamic collaboration with, personal office resources, corporate information system, project information, project partners, internet resources, all necessary skills, and all useful data on the user's environment.</li><li>Such a continuous link with the company and project partners will allow More efficient business processes (on site) and reduce current loss of time for decision-making, planning, etc.</li></ul>															
<b>Techno-logical objectives</b>		<ul style="list-style-type: none"><li>An environment (a virtual workplace) that provides mobile workers with context-based asynchronous and synchronous basic &amp; advanced collaborative services, e.g. terminal and network adaptation, secure communication, smart access to all project documentation, vertical services for instant collaboration and remote decision, etc.</li></ul>															
<b>Approach</b>		<ul style="list-style-type: none"><li>Develop new ICT-supported business processes &amp; working practices for mobile workers</li><li>Investigate use of advanced mobile and ambient technologies (PAN, LAN et WAN wireless networks, multi-sensorial devices, wearable appliances, GPS and other 3D location technologies, sensors, RFID and other tagging/identification systems, etc.) to construction work</li><li>Apply baseline technologies for real-time and secure point-to-point or point-to-multipoint connectivity</li><li>Develop unified and intelligent information systems to access data/information/knowledge organised around a nD-model of the project</li><li>Develop specific (vertical) applications for mobile workers (e.g. on site simulation, site management, site resources tracking, planning, site security &amp; workers safety, supply chain management, remote collaboration, etc.)</li><li>Need for expertise in telecommunications and security systems, mobile devices, ambient technologies, process analysis, etc.</li></ul>															
<b>Results</b>		<ul style="list-style-type: none"><li>Real-time capture system allowing to register all useful site information/event</li><li>Global searching tool (search for information, for expertise...)</li><li>Real-time communication between actors (audio, video) using advanced multi-sensorial interfaces</li><li>Vertical collaboration services</li></ul>															
<b>Exploitation</b>		<ul style="list-style-type: none"><li>Main use of results by construction mobile workers (project managers, contractors, sub-contractors, suppliers,...)</li><li>Development and exploitation of the environment (with specific vertical applications) by software vendors, jointly with R&amp;D institutes, including commercial agreement with device manufacturers, telecommunication service providers and integrators</li></ul>															
<b>Impacts</b>		<ul style="list-style-type: none"><li>Instant / ubiquitous access to any kind of useful information / knowledge</li><li>More efficient working methods, ubiquitous visibility of work progress, improved workflow</li><li>Improved reactivity and speeding up of decision process</li></ul>															
<b>Follow-up actions</b>		Change of culture and behaviours, especially on construction site															
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## Knowledge Sharing

Strategic Action	Objectives
<b>Intelligent product catalogues</b>	Technologies and standards for publishing, searching and using model based information about manufactured building components.
<b>Semantic Search framework for AEC</b>	<p>An environment able to:</p> <ul style="list-style-type: none"> <li>• interoperate with semantic data resources pertaining to the AEC domain (or sub-domains), including potential syndication and consolidation of data;</li> <li>• manage the required ontologies (concepts descriptions) so as to manage common or mapped information provided by various actors;</li> <li>• provide the user with advanced interfaces for seamless querying;</li> <li>• integrate the set of required algorithms allowing the intelligent treatment of queries, appropriate processing of knowledge, and synthesis and ranked (e.g. according to some weight) presentations of answers.</li> </ul>
<b>Shared knowledge for efficient collaboration in Construction</b>	Semantic repositories (based on ontologies/taxonomies) allowing to <i>formally</i> represent the knowledge used during the development of any Construction product; semantic mappings between those repositories. The ultimate goal is the capitalisation of the knowledge required to produce a construction product. Additionally, the process followed to create these referentials and mappings will be formalised and proposed as a methodological approach.
<b>Standardised Libraries and Behaviours in Construction</b>	<ul style="list-style-type: none"> <li>• Technologies and standards for publishing, searching and using model based information about manufactured building components.</li> <li>• Standardised descriptions of products across Europe, and as far as possible across the world, for the 80% most commonly used products.</li> </ul>
<b>Tacit Knowledge Capture and Articulation</b>	Innovative ways of working, improving business performance, creating a life-long learning environment, innovations in construction processes.
<b>Utilizing best practice db in rule based systems for the AEC industry</b>	<p>The innovation is to;</p> <ul style="list-style-type: none"> <li>• Develop an <b>interoperable knowledge architecture</b> for AEC industry</li> <li>• Develop a <b>system architecture for rule based systems</b> for this domain</li> <li>• Describe <b>knowledge</b> as rules based on IFC and other buildingSMART standards</li> <li>• Develop <b>demonstrators</b></li> <li>• Develop a <b>knowledge value chain</b> model and outline a <b>knowledge ecology</b></li> </ul>
<b>O.I.B.E. An Online Informationcenter for Building and Electrosensitivity</b>	<p>Innovation is related to:</p> <ul style="list-style-type: none"> <li>• patient related collection of data,</li> <li>• technical environment related collection of data,</li> <li>• inter- and transdisciplinary processing of technical environment related and</li> <li>• patient related parameters in order to develop a pathogenesis-model for electrosensitivity.</li> </ul>



## Intelligent product catalogues

<b>Keywords</b>	catalogue, product, manufacturing, customisation, web service					
<b>Time to industry</b>		Short term	X	Medium term		Long term
<b>Topic area</b>	X	2. Industrialised production	o	3. Digital models	X	7. Knowledge sharing
<b>Industrial problem / relevance</b>	Buildings are increasingly composed of prefabricated components and manufactured products that are procured from various sources and assembled on site. In order to link the supply and demand, the product information needs to be made available for search, comparison and re-use in various model based tools.					
<b>Technological objectives</b>	Technologies and standards for publishing, searching and using model based information about manufactured building components.					
<b>Approach</b>	Develop methodology & language for describing product information: attributes and customisation logic. Merge technologies like GDL, IFC, OWL, XML. Incremental migration with close linking of prototyping, industrial validation and implementation. Assuring critical mass by involvement on key players and parallel standardisation.					
<b>Results</b>	<ul style="list-style-type: none"> <li>• Taxonomy &amp; ontology of building components.</li> <li>• Product description methodology.</li> <li>• Content authoring &amp; management tools.</li> <li>• Context aware search and presentation methods.</li> <li>• End-user tools and web service platforms with open interfaces.</li> <li>• EU-wide network of interoperable content providers.</li> </ul>					
<b>Exploitation</b>	<ul style="list-style-type: none"> <li>• Software vendors will provide application tools and web service platforms.</li> <li>• Manufacturers will provide catalogues of their products.</li> <li>• Web service providers &amp; information brokers will publish contents.</li> <li>• Users of manufactured products can access catalogues with tools of their own choice without being forced to use the same technology as the manufacturer / information broker. Information can be delivered to a user with personalised contents according to his needs / profile.</li> <li>• Product intelligence (e.g. design rules, constraints etc.) can be embedded into catalogue object off-loading designers from repetitive calculations with various application softwares.</li> </ul>					
<b>Impacts</b>	<ul style="list-style-type: none"> <li>• European wide market and visibility to product information.</li> <li>• Catalytic industry-wide impact boosting industrialization of construction via open access to information about manufactured products.</li> <li>• Knowledge based construction sector: commercialization and mass-distribution of knowledge.</li> <li>• New business opportunities to specialized companies: manufacturers, catalogue object creators, information brokers.</li> </ul>					
<b>Follow-up actions</b>	Standardisation. Critical mass of contents. Interfaces and add-ons for popular tools. Development of business models.					
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## Semantic Search framework for AEC

Keywords	Semantic-based knowledge, search engine, optimised information				
Time to industry		Short term	X	Medium term	Long term
Topic area	o	6. Collaboration support			X 7. Knowledge sharing
Industrial problem / relevance	The overall amount of information is growing at such a pace that new smart systems must leverage knowledge and exploit it efficiently for people. Besides regular web search facilities, there is need for business search services based on more advanced search technologies. A semantic search framework for AEC is to provide to the final AEC users means to query information sources in Intranets and over the Web through natural languages and/or natural interfaces, while reducing search noise (e.g. up to 95%) and achieving a high degree of users' satisfaction (e.g. no less than 90%).				
Technological objectives	<p>An environment able to:</p> <ul style="list-style-type: none"><li>• interoperate with semantic data resources pertaining to the AEC domain (or sub-domains), including potential syndication and consolidation of data;</li><li>• manage the required ontologies (concepts descriptions) so as to manage common or mapped information provided by various actors;</li><li>• provide the user with advanced interfaces for seamless querying;</li><li>• integrate the set of required algorithms allowing the intelligent treatment of queries, appropriate processing of knowledge, and synthesis and ranked (e.g. according to some weight) presentations of answers.</li></ul>				
Approach	Relying on advanced technologies like the Semantic Web, AI techniques (e.g. natural language, object recognition, statistical machine learning, rule inferencing...), the considered model-driven approach is to develop a framework on 3 fundamental pillars: one for the structured search, one for the linguistic indexation, and the third one for the semantic search. The 3 components have to work in parallel on the bases of various algorithms and multiple semantic and linguistic rules (for better understanding of queries and improved analysis of potential answers)				
Results	<ul style="list-style-type: none"><li>• The full specification of an architecture for search of semantic-based textual and media knowledge, dedicated to the AEC domain;</li><li>• A search-oriented metamodel (concepts, relationships, rules, context description) for semantic descriptions and reasoning on knowledge;</li><li>• A set of functional specifications for queries in natural language and/or through natural interfaces;</li><li>• An SOA-based (with potential levels of quality) framework integrating various search modules for optimised drilling and relevance checking of information.</li></ul>				
Exploitation	<ul style="list-style-type: none"><li>• Potentially any AEC stakeholders already using dedicated tools like CD-REEF in France;</li><li>• Enterprises' workforces to react in a highly flexible and productive manner.</li></ul>				
Impacts	<ul style="list-style-type: none"><li>• Focus on specific body(ies) of knowledge) and applying AI techniques will reveal more economical and efficient: rid of the noise, reduce the amount of information, compute information, (not just ranking and/or linking);</li><li>• Enhanced exploitation of already large (and ever increasing) collection of documents dedicated to the AEC domain over the Web;</li><li>• Improved rates of adequate decisions &amp; trade-offs thanks to a more viable / targeted information in Construction processes.</li></ul>				
Follow-up actions	Move towards standardisation bodies.				
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## Shared knowledge for efficient collaboration in Construction

Keywords	Ontology, product, web service				
Time to industry		Short term	X	Medium term	Long term
Topic area	o	2. Industrialised production			o 5. Interoperability
	X	6. Collaboration support			X 7. Knowledge sharing
Industrial problem / relevance	A construction product is a complex object that has its own life cycle and requires the collaborative work of experts having complementary skills coming from different communities. This situation leads to an overabundance of information and a low level of knowledge capitalisation / reuse taking into account that each phase of the production process may involve several companies (likely very heterogeneous). Enhancing the sharing of knowledge within and among these actors will increase the productivity and ease the collaboration among partners.				
Technological objectives	Semantic repositories (based on ontologies/taxonomies) allowing to <i>formally</i> represent the knowledge used during the development of any Construction product; semantic mappings between those repositories. The ultimate goal is the capitalisation of the knowledge required to produce a construction product. Additionally, the process followed to create these referentials and mappings will be formalised and proposed as a methodological approach.				
Approach	Relevant scenarios (based on real cases) suggested by key actors from Construction; outputs from European research projects and international initiatives (Dublin Core, ebXML, CoMMA, eConstruct); Web based and “semantic” technologies (Web services, OWL, ...); and “Construction oriented” standards (IFC, bcXML, ...).				
Results	<ul style="list-style-type: none"><li>• Semantic (domain-oriented) repositories to be exploited in the selected scenarios;</li><li>• Table of (semantic) mappings between semantic repositories + a methodology to create and maintain the mappings</li><li>• Software solutions allowing AEC companies to annotate through structured assertions their daily work + semantic based search engine(s) to retrieve existing knowledge on given topics</li><li>• Semantic search tools / services / frameworks</li></ul>				
Exploitation	<ul style="list-style-type: none"><li>• Two main targets: (i) AEC companies: the ontology(ies) will constitute semantic repository(ies) allowing them to capitalise on their own production (products, projects, documents, etc.) ; (ii) Content providers: all information producers are potentially targeted by such services – with provision of semantic descriptors and allowing the comparison between products</li><li>• Software solutions can be distributed as application tools or web service platforms.</li></ul>				
Impacts	<ul style="list-style-type: none"><li>• Knowledge created during the development of a construction product is formalised for further capitalisation / re-use</li><li>• Provide “intelligent” indexing &amp; integration of information / knowledge; and thus enable the integration / reuse of this knowledge.</li><li>• The collaboration among partners during the production of construction products is simplified.</li></ul>				
Follow-up actions	Move towards standardisation bodies.				
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## Standardised Libraries and Behaviours in Construction

<b>Keywords</b>		Semantics, Ontologies, Libraries, Behaviours, Catalogues				
<b>Time to industry</b>		Short term	X	Medium term		Long term
<b>Topic area</b>	X	3. Digital models	X	5. Interoperability	X	7. Knowledge sharing
<b>Industrial problem / relevance</b>	<ul style="list-style-type: none"> <li>• Differences in product names, definitions and behaviours make generic sourcing of products from web-based libraries impossible.</li> <li>• Currently libraries are electronic versions of national paper catalogues.</li> <li>• Drivers for change are speed, accuracy and competitiveness.</li> </ul>					
<b>Technological objectives</b>	<ul style="list-style-type: none"> <li>• Technologies and standards for publishing, searching and using model based information about manufactured building components.</li> <li>• Standardised descriptions of products across Europe, and as far as possible across the world, for the 80% most commonly used products.</li> </ul>					
<b>Approach</b>	<ul style="list-style-type: none"> <li>• Develop methodology and language for describing product information using attributes and customisation.</li> <li>• Merge technologies like GDL, IFC, IFD, OWL, XML, moving from static attributes to behaviours.</li> <li>• Incremental migration linking prototyping, industrial validation and implementation, using framework to ascertain user requirements and template for manufacturers to populate.</li> <li>• Worked examples to test validity of processes and media in several languages.</li> </ul>					
<b>Results</b>	<ul style="list-style-type: none"> <li>• Taxonomy and ontology of building components.</li> <li>• Product description methodology.</li> <li>• Content authoring and management tools.</li> <li>• Context aware search and presentation methods.</li> <li>• End-user tools and web service platforms with open interfaces.</li> <li>• EU-wide network of interoperable content providers.</li> </ul>					
<b>Exploitation</b>	<ul style="list-style-type: none"> <li>• Software vendors will provide application tools and web service platforms.</li> <li>• Manufacturers will provide catalogues of their products.</li> <li>• Web service providers and information brokers will publish contents.</li> <li>• Users access catalogues to obtain personalised content with tools of their choice.</li> </ul>					
<b>Impacts</b>	<ul style="list-style-type: none"> <li>• Europe-wide market and visibility for product information and purchase.</li> <li>• Boost to industrialization of construction via open access to information about manufactured products, relieving designers from repetitive calculations.</li> <li>• Commercialization and mass-distribution of knowledge.</li> <li>• New business opportunities for catalogue object creators, information brokers.</li> </ul>					
<b>Follow-up actions</b>	Standardisation. Critical mass of contents. Interfaces for procurement, design and FM. Add-ons for popular tools. Development of business models.					
<b>Name</b>	Per Jaeger		<b>Org.</b>	Bougprodusentene	<b>Email</b>	per.jaeger@boligprodusentene.no

## Tacit Knowledge Capture and Articulation

Keywords	tacit knowledge, organisational learning, business performance, knowledge management system, organisational culture				
Time to industry		Short term		Medium term	x Long term
Topic area	x	1. Value-driven business processes			x 7. Knowledge sharing
Industrial problem / relevance	In order to prevent the loss of knowledge (especially tacit) gained in construction projects, effective knowledge management is needed. The main drivers are the need for innovation, improved business performance, client satisfaction, encourage continuous improvement, reduce rework, develop new products & services.				
Technological objectives	Innovative ways of working, improving business performance, creating a life-long learning environment, innovations in construction processes.				
Approach	<ul style="list-style-type: none"><li>• Develop methodology / framework for capturing tacit knowledge in construction projects</li><li>• Develop a model to encourage employees within the firm to share knowledge</li><li>• To implement in practice, develop a web-based system, using technologies such as XML, by which tacit knowledge can be managed effectively within the companies</li></ul>				
Results	<ul style="list-style-type: none"><li>• Knowledge management framework / methodology for capturing &amp; sharing tacit knowledge</li><li>• Knowledge management system will be developed</li><li>• User-friendly system implementation within the company</li></ul>				
Exploitation	<ul style="list-style-type: none"><li>• Access to required knowledge will be provided by the developed system</li><li>• Every company user will access to the system</li><li>• Different user level authorizations</li></ul>				
Impacts	<ul style="list-style-type: none"><li>• Immediate access to the right knowledge at the right time</li><li>• Reduction in repeated works in construction projects</li><li>• More innovative approaches in business</li><li>• Improvement of business performance of construction companies</li></ul>				
Follow-up actions	<ul style="list-style-type: none"><li>• Organisational culture support for knowledge sharing</li><li>• Establishment of a knowledge management team within the companies</li></ul>				
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**Utilizing best practice database in rule based systems for the AEC industry**

<b>Keywords</b>		rules, semantic technology, knowledge value chain, knowledge ecology					
<b>Time to industry</b>			Short term	X	Medium term	X	Long term
<b>Topic area</b>	Process :	x	1. Value-driven business processes			x	2. Industrialised production
	Product :	x	3. Digital models				4. Intelligent constructions
	Project :	x	5. Interoperability				6. Collaboration support
	Enterprise :	x	7. Knowledge sharing			x	8. ICT enabled business models
	Other :	x	Semantic technologies				
<b>Industrial problem / relevance</b>		Much of today's software development <i>encapsulates important knowledge</i> and we lack interoperability standards for <i>knowledge exchange</i> . The challenge for the global AEC industry is therefore to develop rule technology that enables direct manipulation of the knowledge base underlying software tools and to develop standards for knowledge interoperability.					
<b>Technological objectives</b>		The innovation is to; • Develop an <b>interoperable knowledge architecture</b> for AEC industry • Develop a <b>system architecture for rule based systems</b> for this domain • Describe <b>knowledge</b> as rules based on IFC and other buldingSMART standards • Develop <b>demonstrators</b> • Develop a <b>knowledge value chain</b> model and outline a <b>knowledge ecology</b>					
<b>Approach</b>		By using an existing best practice knowledge base (e.g., BKS from Norway) we can focus on a set of trivial problems defining base cases for developing a knowledge and system architecture, define necessary rule bases and develop demonstrators.					
<b>Results</b>		An interoperable knowledge architecture, a system architecture for rule based systems, knowledge sets (dbs) described as rules based on buildingSMART standards and example of a possible knowledge value chain.					
<b>Exploitation</b>		Exploitation will be by <i>software companies</i> -deploy industry rule databases and develop rule systems, <i>best practice providers</i> -develop rule databases, <i>architectural and engineering companies</i> -deploy solutions and develop company specific rule bases that can supplement/override industry best practices databases and <i>authorities</i> - develop rule sets for checking.					
<b>Impacts</b>		Potential benefits are improved knowledge management both within companies and across the industry, increased capacity for performing knowledge intensive work without increasing head count, and provide EU with a potential edge in the development of the global knowledge society.					
<b>Follow-up actions</b>		The whole AEC industry system (companies, authorities, educational institutions and R&D) need to understand the implications of this rule technology and re-organize the knowledge value chain and knowledge ecology in order to harness the new opportunities.					
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<b>Email</b>		lcc@selvaag.no					



## O.I.B.E. An Online Information center for Building and Electrosensitivity

Keywords	Electrosensitivity, Building Materials, Electromagnetic fields, Communication-Technologies				
Time to industry	X	Short term	X	Medium term	Long term
Topic area	X	7. Knowledge sharing			
Industrial problem / relevance	<p>Human related health-phenomena like electrosensitivity or multiple chemical sensitivity, sick building syndrome or chronic fatigue syndrome, chronic health discomfort like rapid exhaustion, high state of exhaustion, insomnia and reduced resistance to diseases or enhanced proneness to allergies, are seen by medical doctors to an increasing degree as an aftereffect of modern lifestyle. The main question thereby is: „Do the building materials in context with work and living spaces (built environment) and the used information and communication technologies influence these phenomena and disorders?“ Main challenges of the O.I.B.E. are:</p> <ul style="list-style-type: none"><li>a) Collecting and making available technical data about coherences in the field of electrosensitivity.</li><li>b) Collecting and making available medical knowledge in the field of electrosensitivity.</li><li>c) Information exchange on preventive measures.</li><li>d) information exchange in the fields of “Building Adaption” and “New Building”.</li></ul>				
Technological objectives	<ul style="list-style-type: none"><li>• patient related collection of data,</li><li>• technical environment related collection of data,</li><li>• inter- and trans-disciplinary processing of technical environment related and</li><li>• patient-related parameters so as to develop a pathogenesis model for electrosensitivity.</li></ul>				
Approach	<p>Collecting and analysing person-related data in combination with building-data and data of used information and communication technologies (ICT):</p> <ul style="list-style-type: none"><li>a) collecting data and information,</li><li>b) interviews with experts in medical and technical regards,</li><li>c) designing and carrying out multicentric studies along with general and specialized physicians (health professionals specialised in diseases due to environmental factors) and clinics. Examining electrosensitive patients by physicians and evaluation regarding to individual / environment related data.</li><li>d) Demonstrating and analysing the accomplished and recommended technical arrangements (related to built environment) in order to reduce wellbeing or health affecting influences by electromagnetic fields; recommended shielding techniques; preventive strategies.</li></ul>				
Results	<ul style="list-style-type: none"><li>1. Systematic collection and analysis of person related data with respect to the history and causes of human electrosensitivity.</li><li>2. Data-collection and data-analysis concerning environment related parameters of human electrosensitivity.</li><li>3. Collection of information and data-analysis in order to provide a catalogue of recommendations for wellbeing and health supporting construction including advices for interior environment and the integration of ICTs.</li><li>4. Gaining new insights about relations between person related parameters (“individual predisposition”), environment related parameters and the impact of ICTs on the human body.</li></ul>				
Exploitation	Data and information will be made available to all EU-citizens, as well as medical professionals, industry and business.				
Impacts	<ul style="list-style-type: none"><li>a) General contribution to preventive health-protection,</li><li>b) exchange of information about measures to adapt existing buildings in order to reduce health affecting influences,</li><li>c) exchange of information about new construction of buildings,</li><li>d) exchange of information about health prevention for individuals.</li></ul>				
Follow-up actions	Subsequent studies with systematic analysis of buildings connected with the current health status of the observed individuals, to find out possible changes of the health status in correlation with adaptations of environment parameters, individual therapies and embedded information technologies.				
Contact information of the proposer					
Name	Hedda Sützl-Klein		Org.	AON	Email <a href="mailto:hedda.suetzl-klein@aon.at">hedda.suetzl-klein@aon.at</a>



## ICT Enabled Business Models

Strategic Action	Objectives
<b>Active online-thermography in civil engineering</b>	<p>The aim of the project is to develop an active online-thermography system in the field of civil engineering for non-destructive location of structural defects in construction materials. Subsequent to the measurement the data should be structured and directly communicated. The system therefore opens the field of controlling in terms of construction. For example:</p> <ul style="list-style-type: none"> <li>• Energy saving (non-stationary thermal performance of buildings);</li> <li>• Quality of building (surface defects, combined thermal insulation systems, material damages of concrete);</li> <li>• Damages of buildings.</li> </ul> <p>The time of measurement therefore should be drawn out to the whole year because of the fact that the system works on basis of visualizing the temperature conductivity instead of the temperature difference (summer- and wintertime).</p>
<b>Inter-Enterprise Engineering Networks</b>	<p>The goal is to establish an Inter-Enterprise Engineering <b>Network of SMEs</b> to offer <b>maintenance and retrofitting services</b> from “on hand”. Building and process data will be exchanged amongst the different information systems of the partners within this network.</p> <p>State of the art construction project management concepts and platforms are not capable to support such heterogeneous long term collaborations, since they are project centered.</p> <p>The flexible integration of different fixed and mobile IT-systems should support the management of construction project information and processes. New members should be supported to easily join and leave the project consortium while still using their own ICT-applications and processes.</p>

## Active online-thermography in civil engineering

<b>Keywords</b>		Thermography; damages in construction; remote control; data exchange				
<b>Time to industry</b>		Short term	x	Medium term		Long term
<b>Topic area</b>	x	1. Value-driven business processes			x	3. Digital models
	x	5. Interoperability			x	8. ICT enabled business models
<b>Industrial problem / relevance</b>	Active online-thermography is about long term measurement (several hours, days). Via online-monitoring of the observed building, the measurement works can be realized from the inside of the office. In some cases multiple telecommanded cameras provide a dawn out flexibility in measuring and, if necessary, an extension of time in terms of measurement. At the same time costs can be decreased, because of a reduced expenditure of working time. Furthermore, online measurement provides the possibility of accurate timing which belongs to the cycle of measurement, Information about limit values, for example temperature, solar radiation) and in the end it helps reducing the amount of required measurement-data. In addition, it becomes possible to elicit surface defects and communicate them to the construction supervisor (Laptop, PDA). Furthermore, there exists a good opportunity for integrating a self-controlled error detection (e.g.: definition of HOT-Spots at cases of surface detection) within the system.					
<b>Technological objectives</b>	<p>The aim of the project is to develop an active online-thermography system in the field of civil engineering for non-destructive location of structural defects in construction materials. Subsequent to the measurement the data should be structured and directly communicated. The system therefore opens the field of controlling in terms of construction. For example:</p> <ul style="list-style-type: none"><li>• Energy saving (non-stationary thermal performance of buildings);</li><li>• Quality of building (surface defects, combined thermal insulation systems, material damages of concrete);</li><li>• Damages of buildings.</li></ul> <p>The time of measurement therefore should be drawn out to the whole year because of the fact that the system works on basis of visualizing the temperature conductivity instead of the temperature difference (summer- and wintertime).</p>					
<b>Approach</b>	<p>1. Systematic registration of possible fields of application in terms of active thermography;</p> <p>2. Compiling prototype damages to elicit the general framework and the limits of active thermography in civil engineering;</p> <p>3. Establishing a measurement application for remote-controlled recording and wireless data-transfer, including online analysis and providing regulated access.</p> <p>While there exist hardly any studies concerning topic 1 and 2, it would be reasonable in terms of topic 3, to access experiences of active thermography in industrial fields (camera systems, control systems).</p>					
<b>Results</b>	<div><div><ul style="list-style-type: none"><li>• Developing active thermography in civil engineering in use for inspection and monitoring of energy saving actions, the quality of constructions and identifying building and construction defects .</li></ul></div><div><ul style="list-style-type: none"><li>• Developing tools for data transmission and -exchange from the construction site to the working office.</li></ul></div></div>					
<b>Exploitation</b>	<p>In a first stage results will be presented to qualified persons in the field of thermography during the annual thermography-days in Austria, Germany Croatia, France and so on. Furthermore results will be provided in terms of thermographical training (EN 473).</p> <p>Beyond that, applications for clients (architects, construction-manager,...) can be presented in the field of university education as well as in magazines and lectures. The fact that active thermography requires complex measurement-techniques the client himself will not miss the provision of services, but he will have permanent access to the measurement-data and -analysis.</p>					
<b>Impacts</b>	The results of this project will create a brand new measurement technique in the field of civil engineering, providing both enhanced professional knowledge and commercial success.					
<b>Follow-up actions</b>	Presentations about the benefits of using active thermography in the field of civil engineering. Realizing thermographical education (Step 3 EN 473) in terms of qualification.					
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<b>Organisation</b>	TB-Panic, Blindenmarkt 7, 4600 Schleißheim					
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## Inter-Enterprise Engineering Networks

<b>Keywords</b>		Collaboration services, SMEs, PPP, tools for collaboration			
<b>Time to industry</b>		Short term	x	<b>Medium term</b>	Long term
<b>Topic area</b>	X	<b>8. ICT enabled business</b>			
<b>Industrial problem /relevance</b>	The significance of maintenance and retrofitting of buildings increases, since the amount of new construction decreases. New operating concepts like Public Private Partnerships (PPP) are gaining importance. SMEs will play an important role, since they have their “local roots”. However, they usually act as sub-contractors of larger construction companies. To compete with big companies SMEs need to collaborate and offer their services as a bundle. Thus, efficient tools and mechanisms, to flexible organize and manage the information and activities of SMEs, are needed. This places high demands on the methods and models that are used to establish a common, homogeneous collaboration structure.				
<b>Technological objectives</b>	The goal is to establish an Inter-Enterprise Engineering Network of SMEs to offer maintenance and retrofitting services from “on hand”. Building and process data will be exchanged amongst the different information systems of the partners within this network.  State of the art construction project management concepts and platforms are not capable to support such heterogeneous long term collaborations, since they are project centered. The flexible integration of different fixed and mobile IT-systems should support the management of construction project information and processes. New members should be supported to easily join and leave the project consortium while still using their own ICT-applications and processes.				
<b>Approach</b>	<ul style="list-style-type: none"><li>• Review state-of-the-art of VE-platforms in construction related sectors</li><li>• Development of an inter-organisational process modelling methodology based on generic process patterns and Web-Service technology</li><li>• Development of reference models for building maintenance and operation</li><li>• Analyse the availability of performance data,</li><li>• Development of a tool-set that allows transparent, flexible and standardised accessibility of performance data</li><li>• Design and implementation of a software framework to coordinate inter-organisational process performances.</li></ul>				
<b>Results</b>	<ul style="list-style-type: none"><li>• Concept to support long term SME partnerships</li><li>• Modelling methodology for inter-organisational processes</li><li>• Library of generic process patterns for maintenance and retrofitting activities</li><li>• Software framework for the coordination of inter-organisational processes</li></ul>				
<b>Exploitation</b>	<ul style="list-style-type: none"><li>• The results will be distributed to the relevant professional organisations</li><li>• Demonstrator projects will be made available</li><li>• Create modular, web-based training material, to be delivered to different end-user groups (SME, craftsmen, engineering personal, end-users)</li></ul>				
<b>Impacts</b>	The new German government has estimated an investment of approx. €700 billion for maintenance and renovation of the transportation infrastructure and for municipal constructions in the next 5 years.  PPP is becoming more attractive. In the UK up to 20% of public financing is already provided by PPPs. However, PPP-models depend on teamwork between multi-national investors and local SMEs.				
<b>Follow-up actions</b>		None.			
<b>Name</b>	Prof. Karsten Menzel		<b>Organisation</b>	University College Cork	<b>Email</b> k.menzel@ucc.ie

## Appendix C: Strat-CON – FIATECH

### FIATECH Capital Projects Technology Roadmap

FIATECH (2007) has through its membership developed its “Capital Projects Technology Roadmap” (CPTR) [see: <http://www.fiatech.org/projects/roadmap/cptri.htm>]. The prime aim of the roadmap being “to accelerate the deployment of emerging and new technologies that will revolutionize the capabilities of the capital projects industry”. Using a process-centric viewpoint, the CPTR contains 9 basic elements of which 8 (see Figure C 1) can be mapped to Strat-CON’s thematic roadmaps. The only FIATECH CPTR element that cannot be mapped addresses new materials, methods, products and equipment. A comparison between the roadmapping approaches used by FIATECH and Strat-CON is illustrated in Figure C 2.

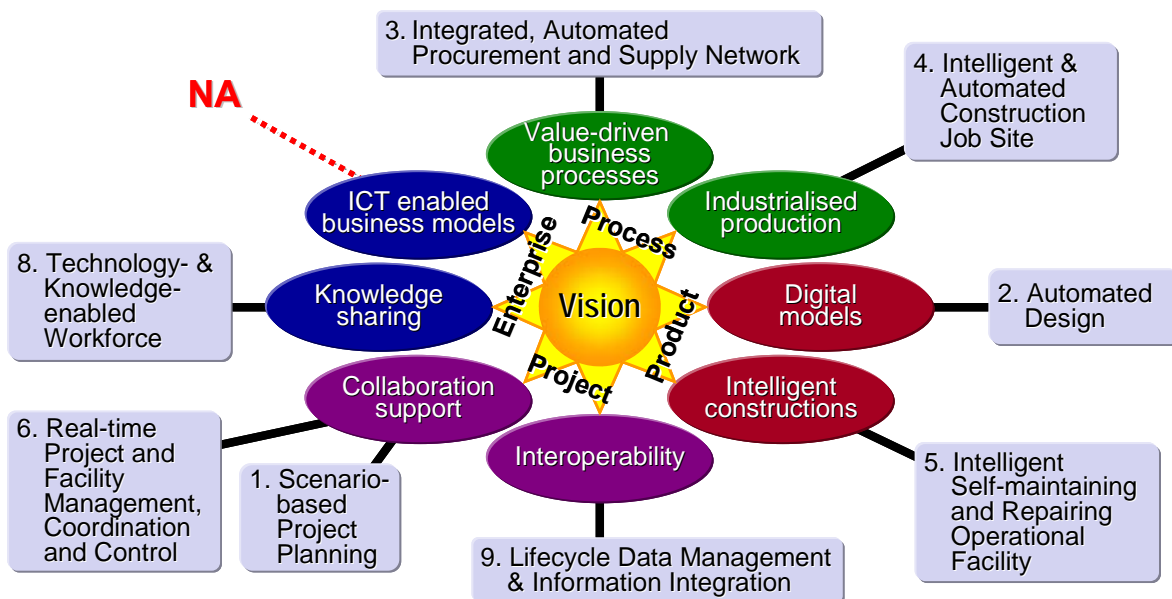


Figure C 1: Complimentarity between FIATECH Capital Projects Roadmap and Strat-CON Roadmaps

	FIATECH	Strat-CON
Approach	9 roadmap elements	8 thematic roadmaps
Focus	Projects	Research topics
Time to Industry	Short => Now	Short, medium & long
View	Process	Technology
Offering	Projects for take-up	Topics for research funding
Main Audience	Industry	National funding bodies
Proposition	Stakeholder benefits	Business scenarios

Figure C 2: Comparison between FIATECH and Strat-CON Roadmap Approaches

## FIATECH – Strat-CON Global Workshop on ICT in Construction

During August 22-24, 2007, a joint global workshop on roadmaps for ICT in Construction between FIATECH and Strat-CON was held in Finland. Through active participation of more than 30 international experts the workshop aimed to develop a series of thematic roadmaps based on common topics of interest of the FIATECH and Strat-CON roadmaps. Focusing on information and communication technologies (ICT) and value driven processes supported through these technologies seven main thematic areas and their respective visions were identified (Figure C 1):

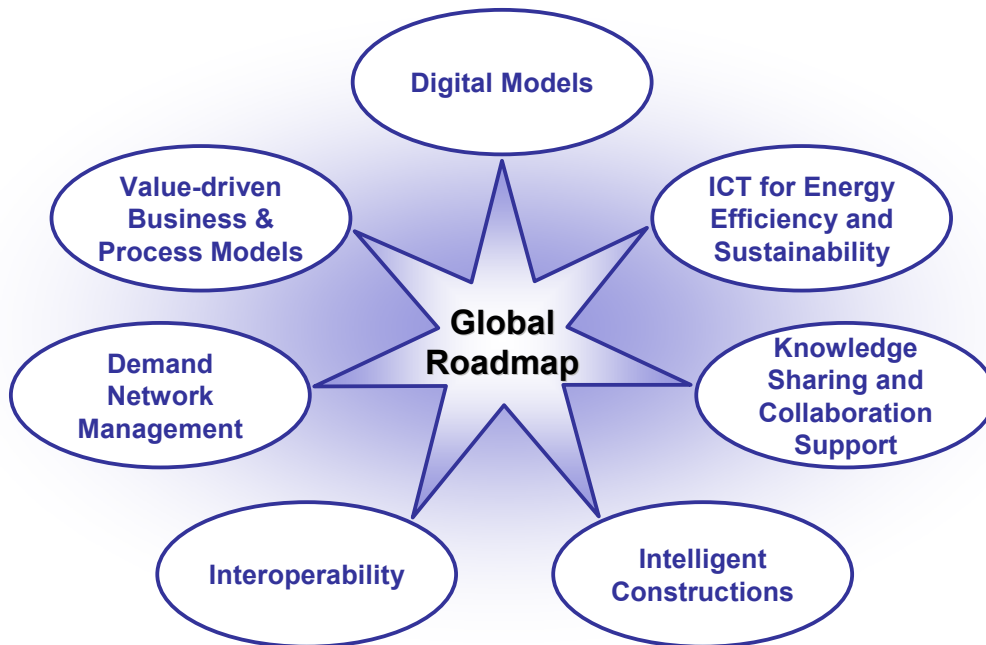


Figure C 3: Main Thematic Areas

**Digital Models:** Digital models are the key enablers for integrating, managing, and sharing multi-disciplinary views and perspectives of the built environment's lifecycle information.

**ICT for Energy Efficiency & Sustainability:** Delivery and use of sustainable and energy-efficient facilities through ICT-based informed decision-making (both human and automated)

**Knowledge Sharing & Collaboration Support:** Seamless and instant access to the right information/knowledge at the right time and in any place

**Intelligent Constructions:** Ubiquitous B2P (B=Building, P=People)

**Interoperability:** Information sharing without concern of the creating system; Interoperability independent of source, life cycle stage and type; Information to be securely accessible and interpretable across the life of the asset

**Network Demand Management:** Customer aware and informed of status at all times and receives on-time delivery; supplier aware of customer and project demands and potential barriers as soon as they arise; environmental requirements included in all future transactions

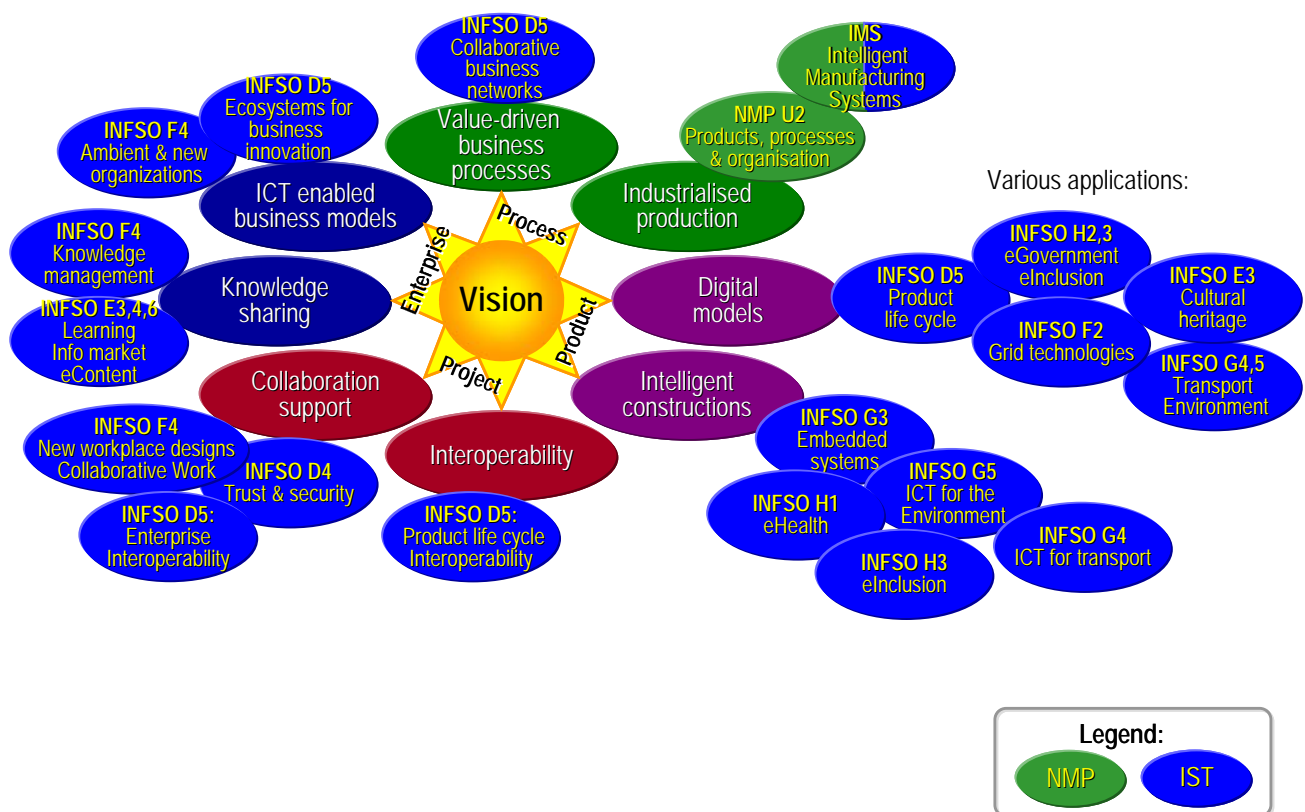
**Value Driven Business & Process Models:** What You Feel Is What You Get

For each of the seven thematic areas, key industrial problems, and current research/technological gaps were identified. These were followed by definition of the vision, main objectives, current state of the art, and roadmaps covering topics for short, medium, and long term delivery to the industry. Furthermore, for each theme, a set of strategic actions (project ideas) to serve as building blocks for projects were identified.

## Appendix D: Strat-CON Mappings

In order to identify relevant resources (contact points, funding opportunities, resources for further information), different mappings were done to the eight main thematic areas of Strat-CON. This appendix presents several examples of such mappings:

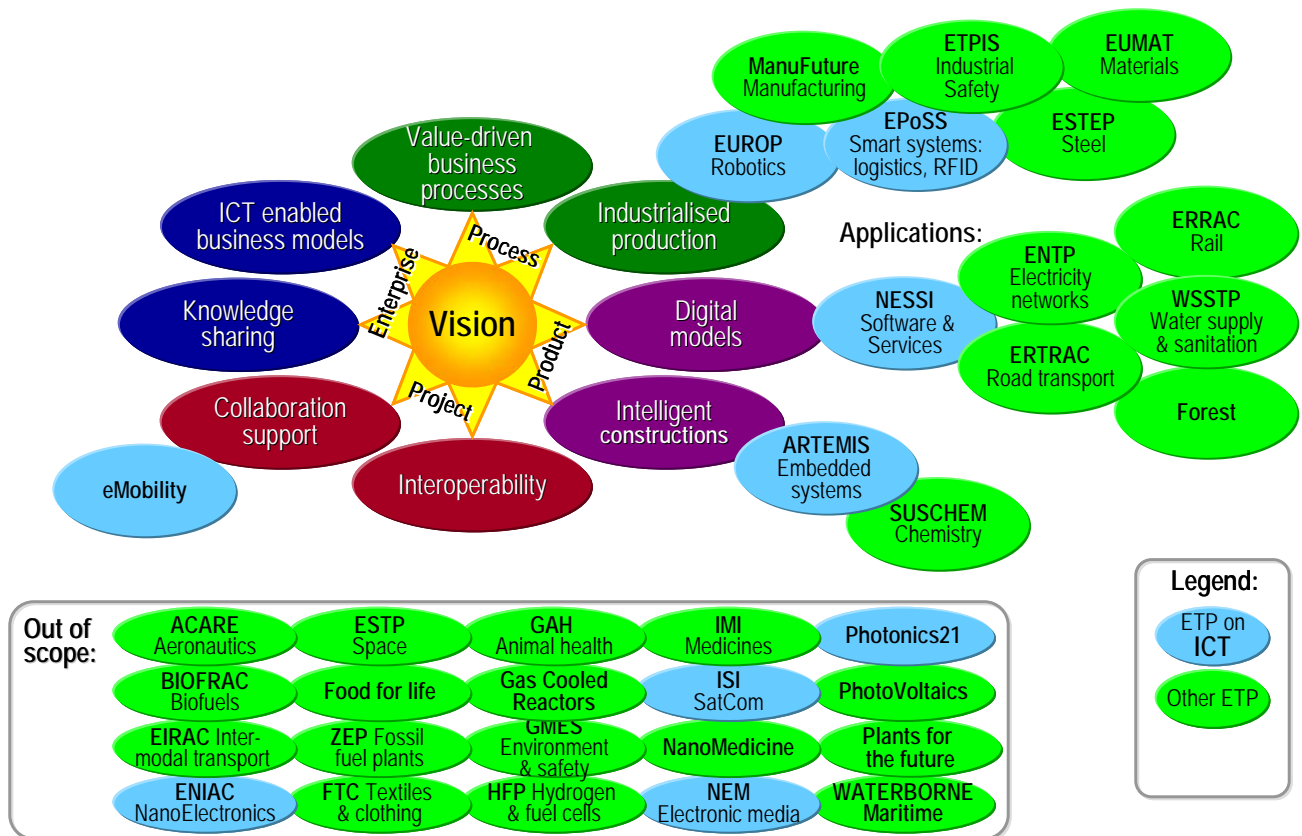
- Figure D 1 presents a mapping to different units of the European Commission who are dealing with similar topics.
- Figure D 2 presents a mapping to different relevant European Technology platforms (note that all Strat-CON themes are covered under Focus Area 7 of the European Construction Technology Platform).
- Figure D 3 illustrates possible sources for seeking project funding through the 1<sup>st</sup> calls for proposals under the European Commissions 7<sup>th</sup> Framework Programme (FP7).



**Figure D 1: Mapping to different European Commission Units**

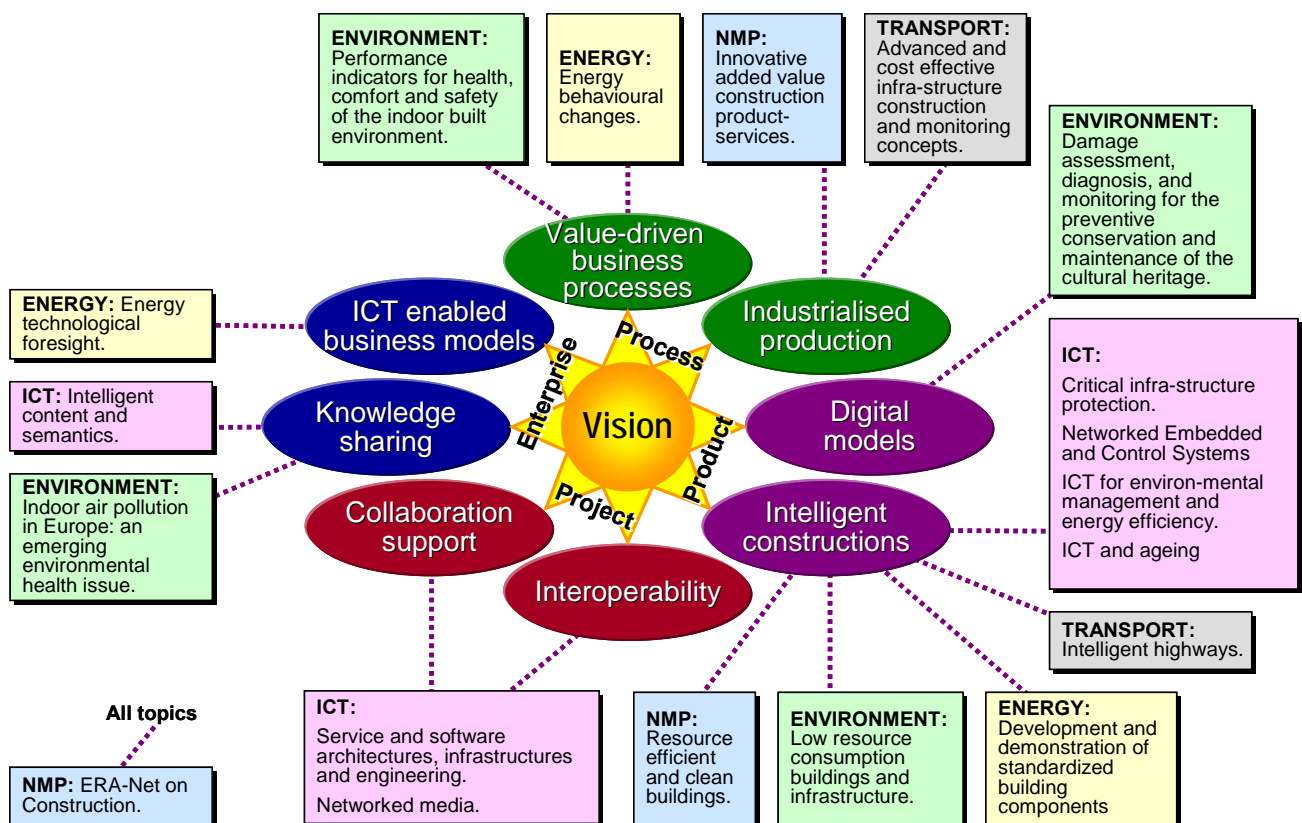
(NMP = Nanotechnology and nanosciences, knowledge-based multifunctional materials and new production processes and devices; IST = Information Society Technologies)





**Figure D 2: Mapping with European Technology Platforms (ETP)**

(Note: Strat-CON roadmaps have a one-to-one mapping with Focus Area 7 of the European Construction Technology Platform [ECTP] )



**Figure D 3: Mapping to Funding Opportunities in 1st Call of Framework 7 of the EC**



## Appendix E: Re-use of Strat-CON Approach

The Strat-CON approach has been effectively used in different contexts to develop strategic roadmaps describing a systematic progression from a current state (as-is) to an envisioned state (to-be). This appendix presents several such examples:

- Figure E 1 presents a roadmap showing progression from proprietary component design and fixed assemblies to ICT-enabled open building systems within the context of the ERABUILD Plug & Play Project on adaptable modular homes.
- Figure E 2 presents a roadmap for developing a technology park for a new foreign university campus of an existing university as commissioned by the higher education authority of where the new campus is to be located.
- Figure E 3 presents a roadmap for Interoperability in the construction industry that was developed during the joint FIATECH and Strat-CON global workshop on ICT in construction (see Appendix C). More roadmaps covering Digital Models, ICT for Energy Efficiency & Sustainability, Knowledge Sharing & Collaboration Support, Intelligent Constructions, Network Demand Management, and Value Driven Business & Process Models and a summary of the workshop outcomes will be available through [http://cic.vtt.fi/projects/stratcon/const\\_IT\\_ws\\_22\\_24082007\\_report.pdf](http://cic.vtt.fi/projects/stratcon/const_IT_ws_22_24082007_report.pdf).
- Figure E 4 presents the results of an exercise aimed at transforming different facets of architectural planning in South Korea. It is based on informed decision making, requirements engineering and management, interoperability across disciplines, and the need for multiple views/perspectives.
- Figure E 5 presents the results of a brainstorming session on configurable and adaptable infrastructure from the perspectives of personal (room), family (home), community (neighbourhood), society (built environment).
- Figure E 6 presents a roadmap for off-shore manufacturing from the Strategic Research Agenda (SRA) of the UK National Platform for the Built Environment. For more information on the SRA and additional roadmaps, refer to Cunningham (2007).

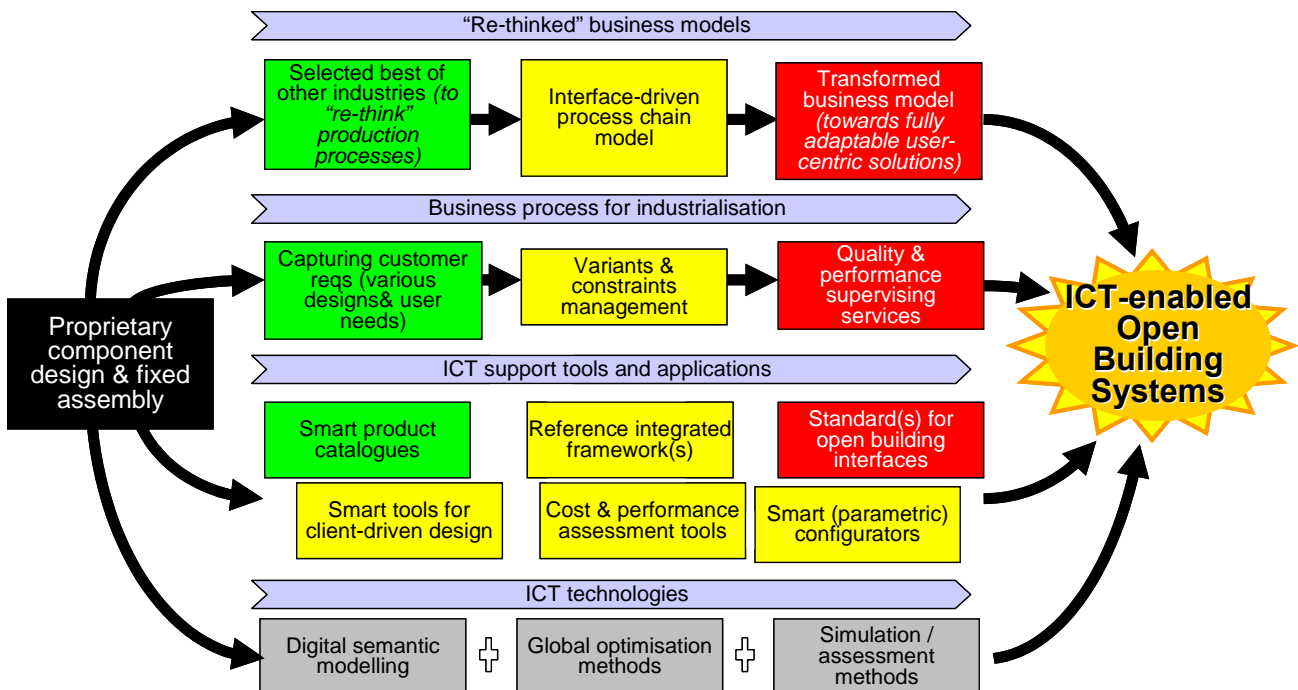


Figure E 1: ERABUILD Plug & Play Project on Adaptable Modular Homes

<b>Objectives</b>	Development of a world class technology park for breeding innovations from ideas to market breakthrough
<b>Enablers</b>	Exiting model from Univ. X, experiences from Univ. X alumni, contacts with high-tech firms and local industry
<b>Barriers</b>	Poor research infrastructure, lack of interest from venture capitalists and business angels, lack of research mindset

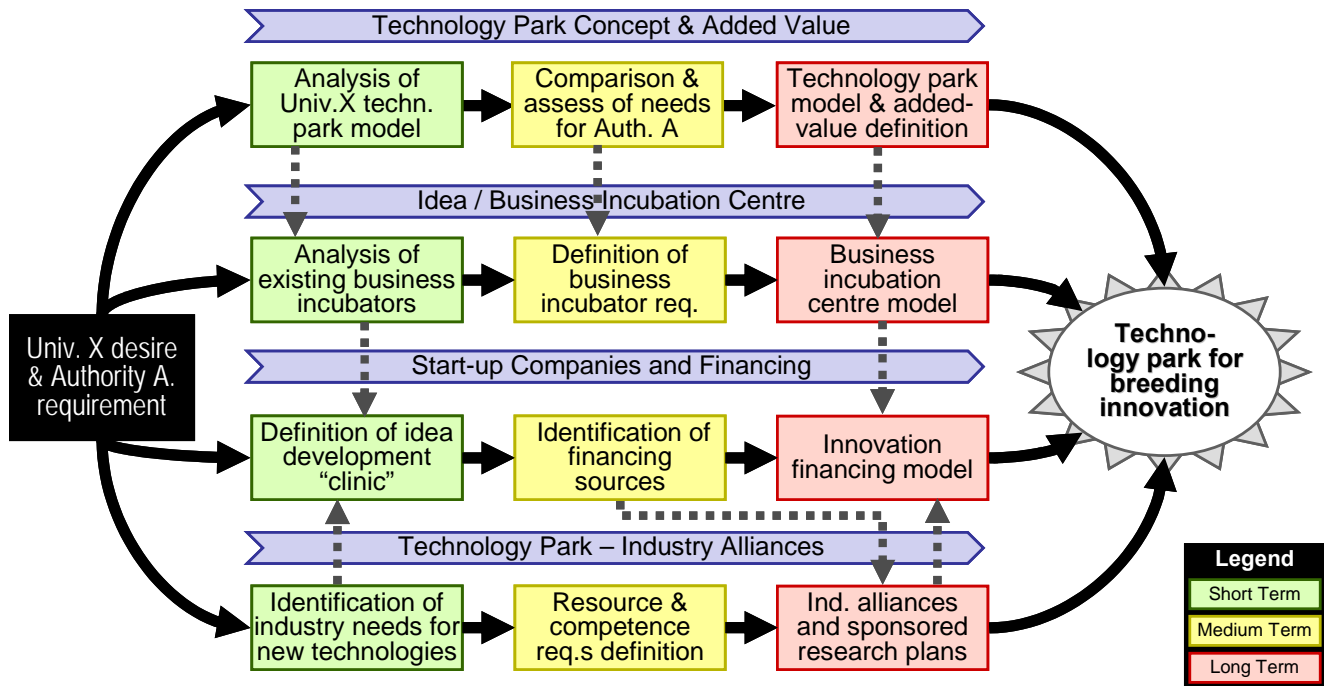


Figure E 2: Technology Park Design for University

<b>Objectives</b>	Provide seamless semantic communication, developing frameworks for interoperability
<b>Enablers</b>	Standards development and adoption. Push by govt, major owners, etc.
<b>Barriers</b>	Equipment manufacturers/suppliers ability to deliver. Plethora of standards. Bespoke solutions.

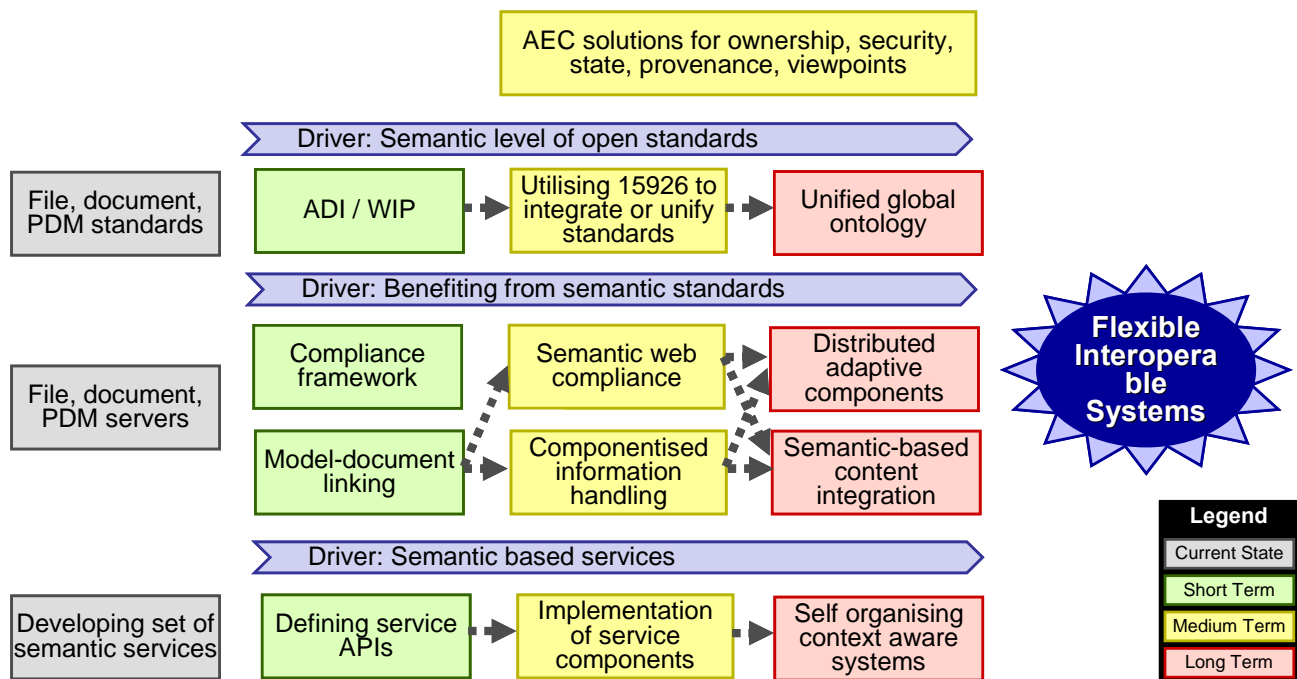
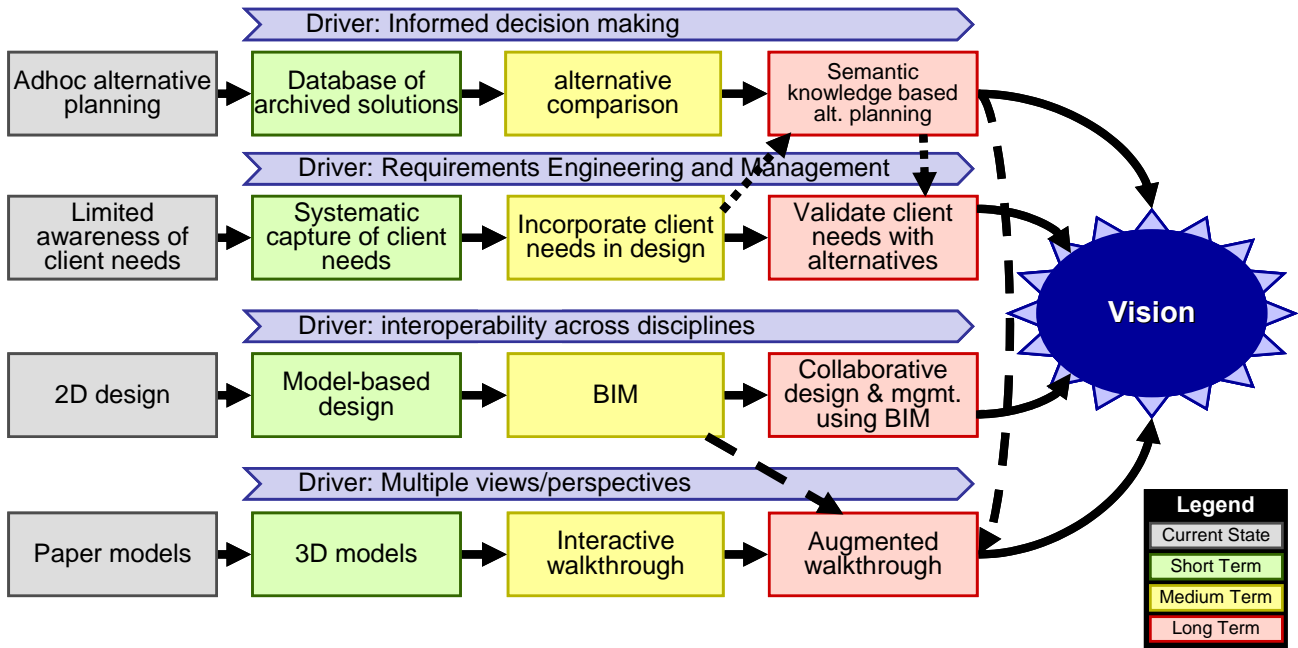
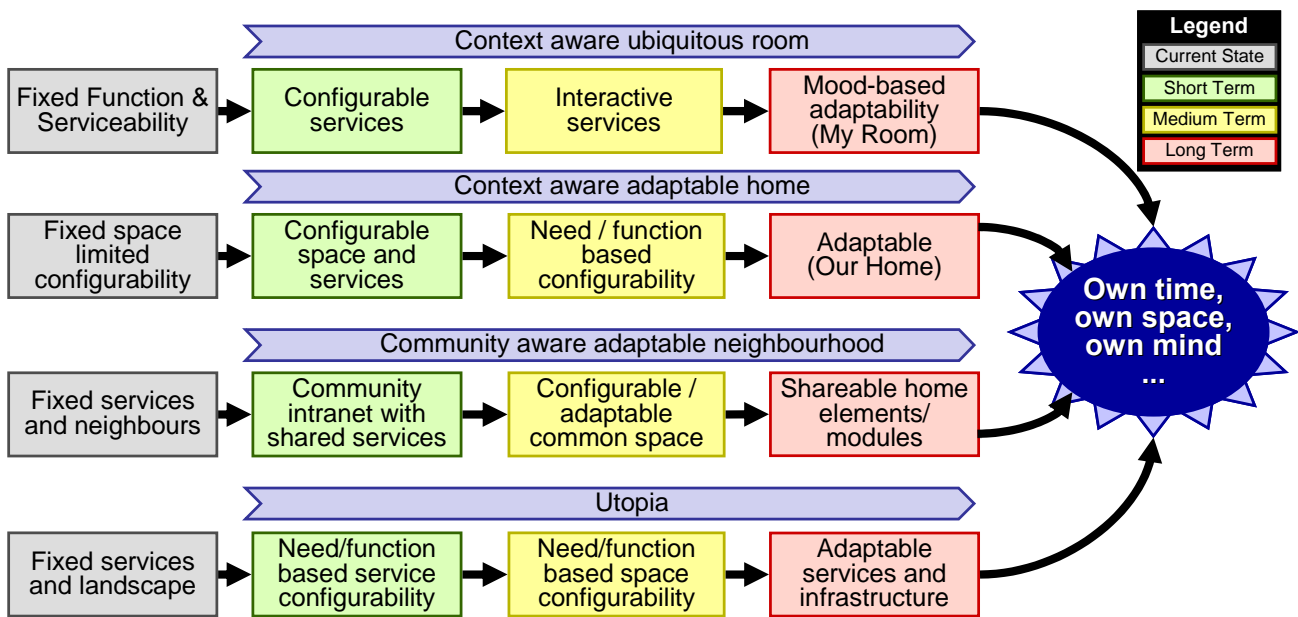


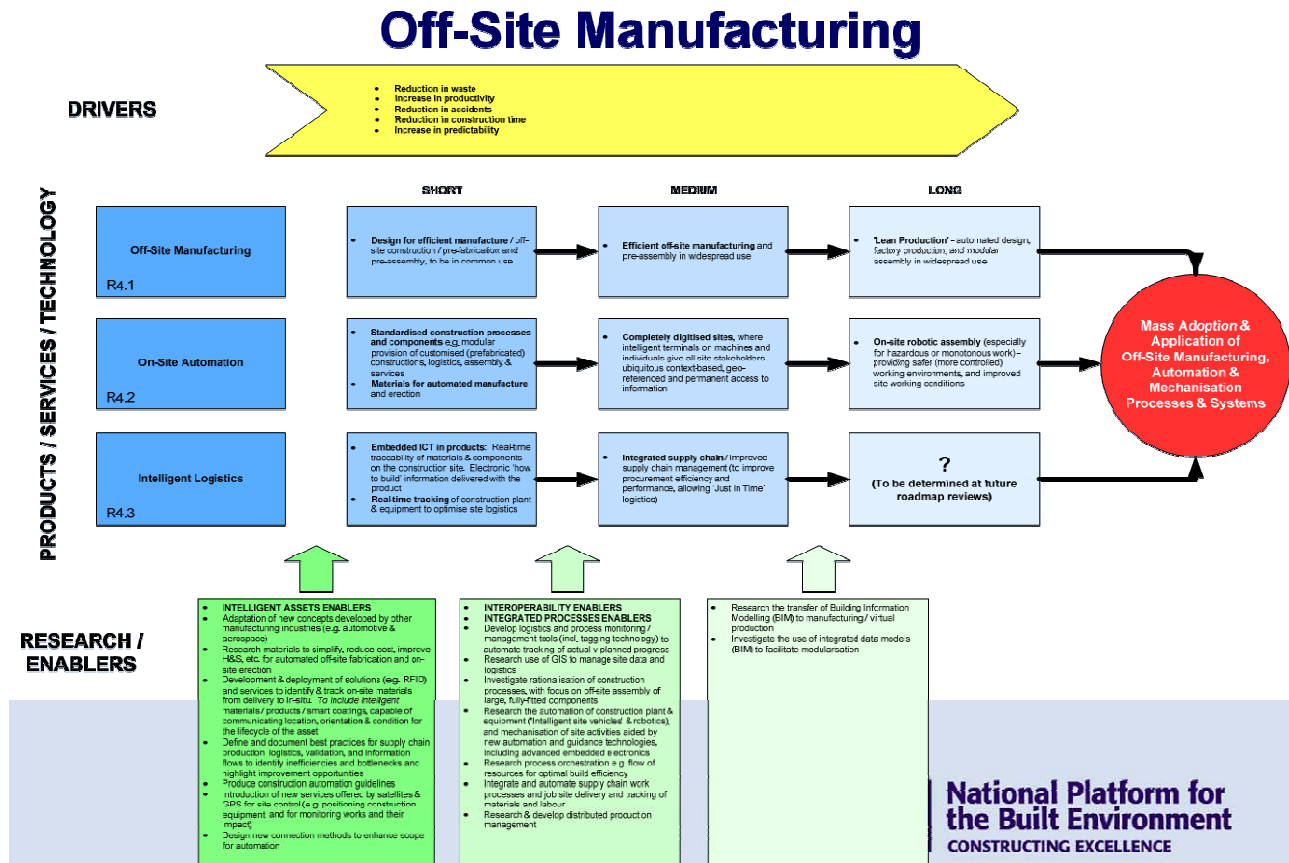
Figure E 3: Interoperability Roadmap from Global Workshop on ICT in Construction



**Figure E 4: Transformation of Architectural Practice in Korea**



**Figure E 5: Configurable and Adaptable Infrastructure**



**Figure E 6: Off-Site Manufacturing - UK National Platform for the Built Environment**  
(Source: Presentation by Peter Cunningham at ECTP 2007 Conference)